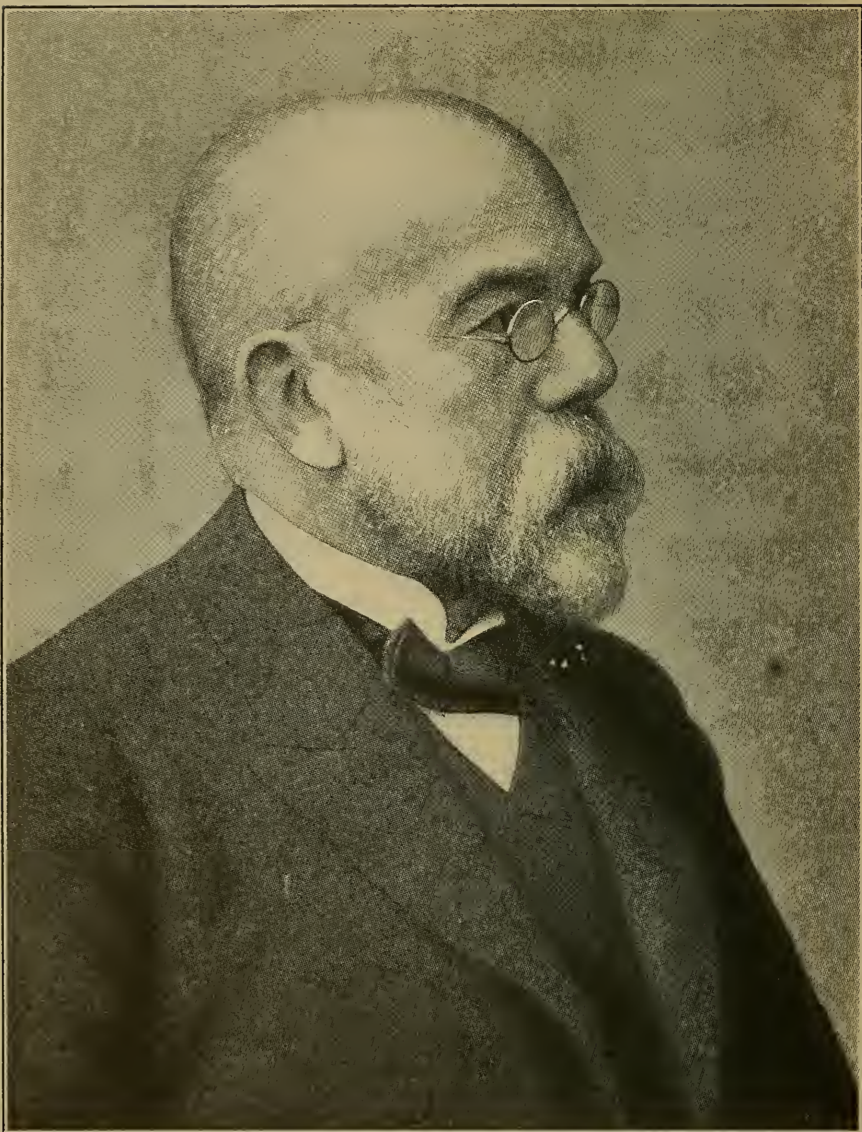

DR. ROBERT KOCH

Who discovered the germ of tuberculosis which kills over four hundred people daily in the United States.

THE HUMAN BODY

AND

HEALTH

AN ELEMENTARY TEXT-BOOK OF ESSENTIAL ANATOMY, APPLIED PHYSIOLOGY, AND PRACTICAL HYGIENE FOR SCHOOLS

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HUMAN BODY.

W. P. I

PREFACE

The most noted of England's prime ministers said, "The first duty of the statesman is the health of the people." One of our own statesmen asserts that the greatest asset of this nation is the health of its citizens. Inasmuch as recent science has shown clearly the cause and prevention of many diseases, it is important that this knowledge should form a part of every individual's equipment for the duties of life. The greatest enemies of the human race are microbes, which annually lay prostrate in this country and Europe seventy million people, of whom three million die. The microbes feeding on human blood have caused the destruction of armies and the downfall of a nation. On this account a knowledge of these infinitely small forms of life is of vast importance.

Since the foundation of many diseases is laid during childhood, and since new ideas are accepted most readily in youth, every boy and girl during school years should be carefully and thoroughly instructed as to the cause of human wretchedness and the means of preventing it. The numerous textbooks on elementary physiology have largely neglected the discussion of facts relating to public health. As a result not one in a hundred graduates of our public schools could state any evidence showing whether vaccination is beneficial or harmful, or describe how malaria, diphtheria, and yellow fever are acquired, and how they may be prevented.

The pupils have spent much time in learning meaningless words, but when information is sought concerning the evidence that typhoid fever is caused by drinking polluted water they remain silent. A pupil is rarely found who can state clearly how the fact has been established that bacteria produce dis-

ease. In consequence very many do not yet believe that disease is preventable, and so pay little heed to the laws made by the state for the welfare of its people.

The facts that in this country nearly one hundred persons die daily of typhoid fever and four times as many from tuberculosis, and that these diseases are largely preventable, are unknown to most public school pupils. As a result the people continue to use bad air, bad water, and bad food. Holmes wrote fifty years in advance of his age: —

> "God gave his creatures light and air
> And water open to the skies;
> Man locks him in a stifling lair
> And wonders why his brother dies."

This book contains a sufficient amount of anatomy to enable the pupil to understand the physiology upon which is based much of the hygiene. Numerous original diagrams, drawings, and halftones from photographs have been introduced to impress upon the learners the most important truths relating to the human machine. For many of the drawings, I am indebted to Professor W. H. Reese of Muhlenberg College.

A considerable number of pages have been given to a discussion of the effects of alcohol on human society, showing that its power for evil is far more marked in producing poverty and crime than in wrecking the physical health.

That a knowledge of practical hygiene does prevent waste of life, is shown by the fact that the death rate per thousand declined from thirty in 1870 to less than nineteen in 1905. Diphtheria, tuberculosis, yellow fever, and malaria claim fewer victims every decade, and when knowledge such as these pages afford reaches all our citizens, the vital records will show a still more rapid decrease in the death rate.

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THE HUMAN BODY AND HEALTH

I. INTRODUCTION

The Meaning of Anatomy. — The science of anatomy describes the parts and structure of the body. It teaches the relative locations of the many organs, such as the heart, lungs, and liver. Without a knowledge of anatomy it would be impossible to understand the operation of the human machine. Ignorance of its operation prevents the proper management, protection, and care necessary to health. Health is wealth, and the lack of health is responsible for much human misery. An understanding of the parts of the body concerned in the preparation of the food, of the vessels conveying it through the body, and of the structures for admitting air and getting rid of waste materials, may be a great aid to human happiness.

The Meaning of Physiology. — This science tells the function, or use, of each part of the human machine. It explains how the food eaten is used to build up muscles, bones, and brain, and how the nerves, heart, and blood perform their duties. The study of physiology helps one to understand the necessity of chewing food thoroughly, by what means the food is taken from the alimentary canal to the head, arms, and legs, and how the brain causes the body to move. It shows how the lifeless bread, meat, and milk may become a part of the living human body, and

how potatoes, oatmeal, or fat meat when eaten may help to keep a person warm.

Importance of studying Physiology. — Knowing how the stomach and intestines act in making the food into a solution to be received by the blood has resulted in finding out the causes of dyspepsia, and also how to prevent it and how to cure it. The discovery of the fact that the germs in old or unclean milk often cause disease and death among infants, has made it possible to prevent much suffering and to save many lives. Until the real use of the blood was understood, patients suffering from various ailments were bled in order to remove the supposedly bad humors from the body.

Prior to the Revolutionary War the insane were commonly thrust into sunless dungeons, and chained to the walls with iron bands riveted about the waist or neck because they were thought to be demons. Since physiology has shown the relation of the mind to the brain and the influence of health upon the brain, the insane have been cared for in a more humane manner. As a result very many recover their health and are restored to their friends. It is only by a clear understanding of the actions of the various organs that one can know when they are out of working order and the kind of remedy to be applied to cure the sickness. The prevention of sickness is, however, far more important than curing it. The greatest benefit, therefore, derived from the study of physiology is the information which enables us to understand *hygiene*.

The Meaning of Hygiene. — The science of hygiene shows how one should live in order to keep the body in a healthy state. It explains how any one may avoid taking cold, and

how to avoid such diseases as yellow fever, typhoid fever, tuberculosis, and malaria. It teaches what to do in case of an injury to the body, such as the breaking of a leg or the cutting of a blood vessel. The success of the Japanese army in the late Russo-Japanese War was in part due to the strict observance of the laws of hygiene by the soldiers and officers of Japan. Army physicians declare that in most wars before the present century, negligence in regard to the laws of hygiene resulted in more deaths than were caused by the bullets of the opposing army.

Importance of studying Hygiene. — A sound body is a fortune. Sickness is expensive. Knowing how to prevent illness is worth more than knowing how to cure it. Before 1796, smallpox was the most dreaded and the commonest of all diseases. In cities having a population of 100,000, more than 2000 cases of smallpox occurred every year, resulting in hundreds of deaths. Some cities suffered from much more severe epidemics. In 1721, Boston, with a population of 11,000, had 5989 cases of smallpox. Eighteen thousand people died of this disease in Iceland during the years 1707–1709. This pest, which once was a great affliction to the civilized world, has now become almost unknown in many regions, owing to vaccination. About one fourth of all children born die in a few months. This is due largely to ignorance and carelessness concerning hygiene, on the part of the parents.

Recent investigations indicate that one half of the 1,000,000 people who died of tuberculosis in this country during the years 1900–1906 might have escaped the disease, or might have recovered from it, by observing the laws of hygiene. Knowing and heeding what hygiene teaches

would have enabled 100,000 of the 200,000 victims of typhoid fever in the year 1906 to escape the malady. Living in a hygienic way has, in Massachusetts, decreased the death rate from tuberculosis one half since 1875. Cities where the water and milk supply are managed according to the demands of hygiene have less than one half as many deaths from typhoid fever as other cities similarly situated but making no special effort to secure pure milk and pure water. Four hundred thousand of the 1,600,000 deaths occurring yearly in the United States could be prevented if the people understood hygiene and lived in accordance with its teachings. Students of this science are confident that 3,000,000 of the 8,000,000 cases of serious illness could be averted by hygienic living.

Value of Hygiene to the Young. — Success in life depends largely upon health. Health depends much upon habits. Habits are formed in youth. The youth is to the future man what the roots are to a tree. The foundation for much of the illness in later life is laid by the boy and girl during school years. That instruction which helps the pupils to understand the care of the body, and the true value of fresh air, proper food, exercise, and cleanliness, will add much to the wealth of a nation and the happiness of its people.

Suggestions for the Teacher

To make the subjects of Physiology and Hygiene of real value, the teacher must impress the more important truths upon the pupils by calling attention to specific facts related to the pupils' own welfare. A few demonstrations and simple experiments are of great use in helping the learners to get correct and well-fixed ideas. Material for showing important structures, such as the heart, larynx, and brain of a calf or a sheep, may be preserved for years in a stone jar or large-

mouthed fruit jar containing a five per cent solution of formalin. This is made by pouring about one third of a teacupful of formaldehyde, to be had at any drug store, into a pint of water.

The writing of short essays on certain topics of vital importance not only will widen the interest and knowledge of the pupils, but also will serve to give valuable training in expression. A few bulletins and reference books may be made to furnish the information for such exercises. Many of the states publish sanitary bulletins or health circulars which may be had free of charge by addressing the State Board of Health at the capital of the state. The following valuable bulletins will be sent free to those requesting them from the Department of Agriculture, Washington, D.C.: Sanitary Milk Production; Rabies or Hydrophobia; Sewage Disposal on the Farm; Source and Nature of Bacteria in Milk; Trichinosis, a Danger in the Use of Raw Pork; How Insects affect Health in Rural Districts; Bovine Tuberculosis and Public Health; Butter Making on the Farm; The Unsuspected but Dangerously Tuberculous Cow; Fish as Food; Eggs and their Uses as Food; The Nutritive Value of Foods; The Care of Milk; Milk as Food.

The following reference books will be helpful to the teacher and should be in every school library.

Overton, Frank, Applied Physiology. American Book Company, N.Y.

Eddy, W. H., Experimental Physiology and Anatomy. American Book Company, N.Y.

Adams, S. H., The Great American Fraud. American Medical Association, 103 Dearborn Ave., Chicago.

Bashore, H. B., Outlines of Practical Sanitation. John Wiley and Sons, N.Y.

Crandall, F. M., How to Keep Well. Doubleday, Page, and Company, N.Y.

Frankland, Mrs. P., Bacteria in Daily Life. Longmans, Green, and Company, N.Y.

Public Health Papers and Reports. C. O. Probst. Columbus, Ohio.

Pyle, W. L., A Manual of Personal Hygiene. W. B. Saunders Company, Philadelphia.

Shaw, E. R., School Hygiene. Macmillan Company, N.Y.

Warwick, F. J., First Aid to the Injured. Penn Publishing Company, Philadelphia.

II. PLAN OF THE BODY

The Cells. — Since the year 1840 it has been known that all plants and animals are made up of one or more tiny lumps of matter called *cells*. A cell, whether in a weed, a worm, or man, consists mainly of a substance named *protoplasm*, which is like the white of a raw egg.

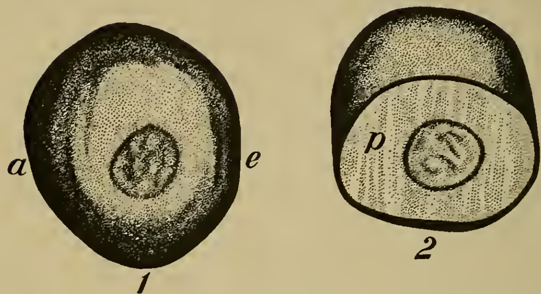


Fig. 1. — A cell much enlarged. 1, surface view; 2, view of the upper part of 1 cut through the line *ae*; *p*, protoplasm; the dark spot is the nucleus and the line around the outside is the cell wall.

A minute and usually spherical body floating in the protoplasm is the *nucleus.* The thin sac ordinarily surrounding the protoplasm is called the *cell wall.* The thin membrane between the successive layers of an onion is formed by a single layer of cells placed edge to edge. Each egg of a toad or frog when first deposited

Fig. 2. — Slipper animalcules in a drop of water. Photographed through the microscope.

is a single cell, but it is more than thirty times as large as the average cell in the human body.

The Nature of a Cell. — The cell is called the unit of life because it is the smallest portion of matter capable of independently living, eating, and growing. A muscle cell, a brain cell, or a skin cell will of course not continue to live long when removed from the body, because it has no means of getting food. There are, however, in most pools of stagnant water thousands of free, living cells, each of which is an animal or plant. One of the largest and very easily found forms of life consisting of a single cell is the *slipper animalcule*, a million of which may be present in a quart dish of water. By adding to a glass of pond water a small bunch of hay or dead grass, and allowing it to stand in a warm room a week or ten days, numerous slipper animalcules may be grown. If a drop of water containing them is placed on a glass slip, they appear to the naked eye like tiny white specks floating about.

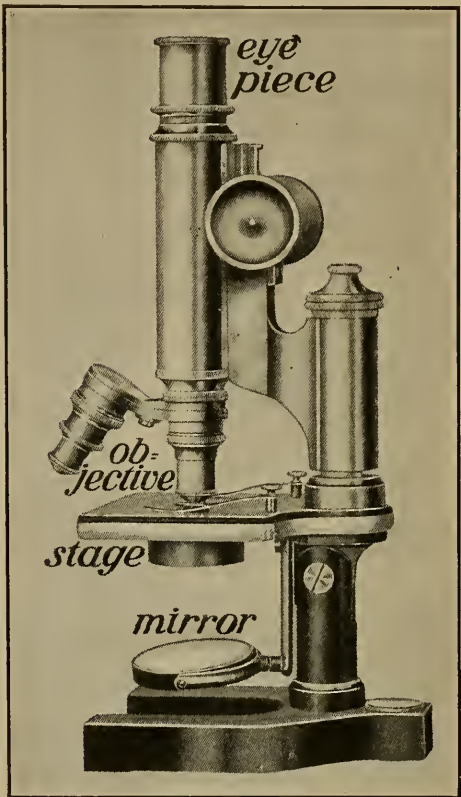


Fig. 3. — A compound microscope such as is used to study the cells of the body and disease germs.

A One celled Animal. — By means of the microscope the slipper animalcule may be seen to have the general shape

FIG. 4. — Drawings of sections of cells. Magnified. *b*, bone cell; *c*, epithelium cell from the intestine; *e*, flat epithelium cell from the mouth; *f*, fat cell; *n*, nerve cell from the brain; *m*, muscle cell.

of a slipper, though its outline changes much when it rubs against an object. The delicate cell wall is elastic and transparent, and is covered with fine hair-like processes called *cilia*, by moving which it swims rapidly. A faintly darker oval spot near the center is the nucleus. It takes in food consisting chiefly of tiny plants called *bacteria*, through a groove on one side. The food, when within the protoplasm, is dissolved, and some of it becomes

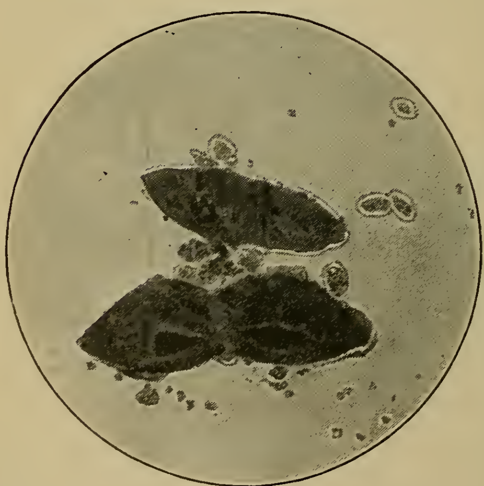


FIG. 5. — Slipper animalcule beginning to divide and thus to form two cells, each of which will swim away as a distinct animal. The nucleus has already divided. Photographed through the microscope.

a part of the animal itself, while the rest is pushed out through the cell wall. This tiny living thing has no bones, muscles, liver, stomach, blood vessels, lungs, or nerves, yet it moves, eats, and gives off the same kind of substances as those cast out by the lungs and kidneys of man. It is affected by heat, cold, light, and touch. This single cell performs a dozen duties, for each of which in the human body there is a separate group of cells.

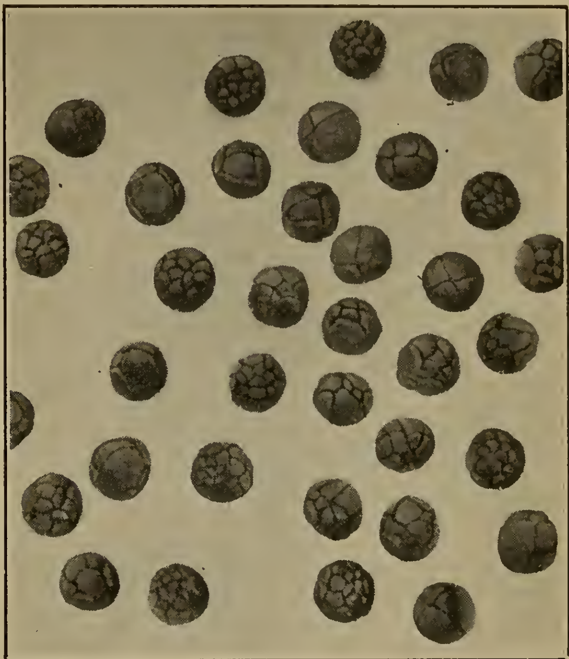


FIG. 6.—Frog's eggs photographed through the microscope. A few hours earlier each egg was a single cell. Some are now seen to be made of four cells, some of eight cells, and others of a greater number of cells.

Kinds of Cells.—In the human body there are more than a score of different kinds of cells. Each kind has a special duty to perform and is worthless for any other service. The *muscle cells* are threadlike and can become shorter or longer to move the bones. The *fat cells* are nearly spherical, while the cells lining the stomach and intestines are columnar and take from the blood something which they change into a juice to dissolve the food. The *nerve cells* are of various shapes, but most of them have

several branching processes, one of which may be two or three feet long. While among the lowest animals one cell serves many purposes, in all the higher creatures there is a different group of cells for each of the processes of life, such as eating, moving, and feeling. This separation of the cells into companies, each with its own special work, is known as the *physiological division of labor.*

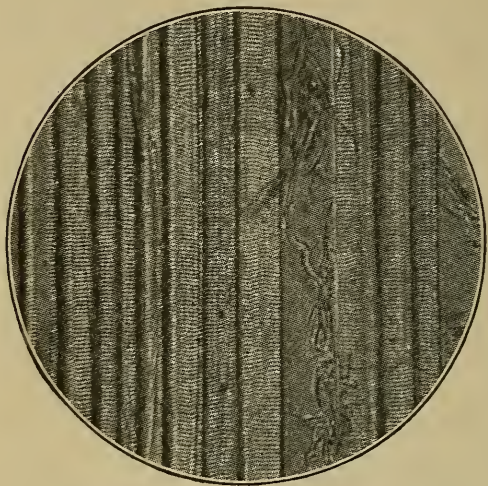


Fig. 7. — A bit of muscle as thick as a hair, photographed through the microscope. In one place the several fibers are separated to show the fibrous connective tissue binding the muscle fibers together.

Growth of Cells. — The slipper animalcule never gets any larger than the point of a pin. As soon as rich food tends to make it grow, the nucleus divides into two parts, and a few minutes later a constriction, or furrow, appears crosswise of the body. The furrow continues to deepen, so that in less than a half hour the tiny creature has separated into two animals. This marvelous process may be easily seen by placing on a glass slide, under the low power of the microscope, a drop of water containing the

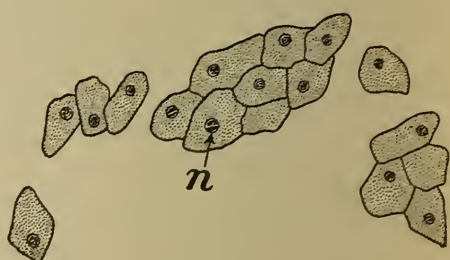


Fig. 8. — Epithelial cells forming the tissue lining the mouth and esophagus. *n*, nucleus. Magnified.

small beings. These two new animals in a few hours grow to full size, and then each divides to form two others. Thus in a few days from one tiny animal may come a thousand. In the same way the cells of the body are increased, but instead of each leading a separate existence they all cling together in one mass. When the upper cells of the skin are rubbed off, the ones in the lower layer divide, and so produce a new lot from week to week.

Fig. 9.—Connective tissue fibers photographed through the microscope.

The Tissues.—A combination of cells of a similar kind forms a *tissue*. The muscle cells constitute the *muscular tissue* known as lean meat (Fig. 7). The nerve cells make up the chief part of the *nerve tissue* composing the brain, spinal cord, and nerves. The epithelial cells, covering the entire body and lining the alimentary canal and other tubes, constitute the *epithelial tissue* (Fig. 8). Numerous cells and fibers serving to bind together the parts of all the other tissues are known as *connective tissue* (Fig. 9). It is this that holds the skin to the muscles and unites the muscles to the bones. It appears as fine weblike threads in a piece of boiled beef picked to pieces on the dinner plate.

Organs.—A group of tissues having a special use is called an *organ*. The heart is an organ for pumping

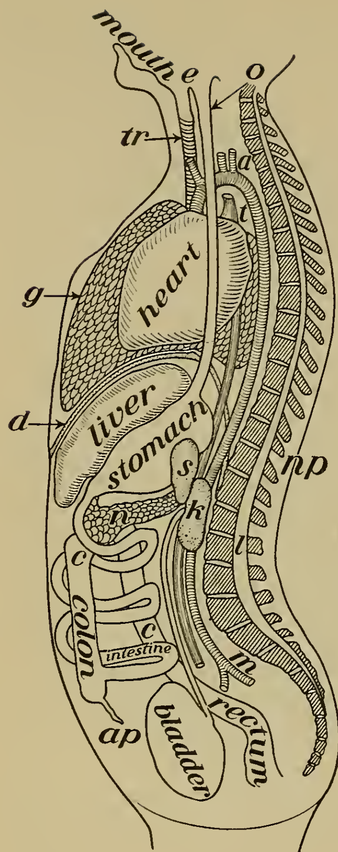


FIG. 10.—Diagram showing the position of the organs of the human body, viewed from the side. *a*, aorta; *ap*, vermiform appendix; *c*, large intestine; *d*, diaphragm; *e*, pharynx; *g*, lung; *k*, kidney; *l*, canal for spinal cord; *m*, branch of aorta to the leg; *n*, pancreas; *np*, spines of vertebræ; *o*, esophagus; *s*, spleen; *t*, vena cava, or great vein; *tr*, trachea

blood, the stomach an organ to digest food, and the brain an organ concerned in thought.

Systems.—Several organs, each of which performs a part of the same general process, constitute a *system.* The *digestive system* is composed of the organs used in digestion. The heart and blood vessels make up the *circulatory system.* The lungs and the air passages of the nose, throat, and windpipe constitute the breathing or *respiratory system.* The kidneys belong to the *excretory system.* All the bones form the bony or *osseous system*, and the muscles form the *muscular system.* The brain, spinal cord, and nerves throughout every part of the body constitute the *nervous system.*

Each system is dependent on the others for its health. When the cells of any tissue do not work properly, the body becomes sick. To keep the body well, each system, each tissue, and each cell must do its own part of the work in preparing, digesting, and using food, and also in giving off waste products of the body. Fresh air,

daily exercise, good food, and temperate habits are the surest means of keeping the systems in working order.

Questions

1. Where are cells found? 2. Name the three parts of a cell. 3. What is a cell? 4. Where can you get animals composed of only one cell? 5. Why cannot a cell removed from man's body continue to live? 6. How does the slipper animalcule live? 7. Name several kinds of cells. 8. Describe how the cells differ in shape. 9. Describe the growth of cells. 10. Define a tissue. 11. Name some tissues. 12. What is an organ? 13. How many systems in the body? 14. What is the best way to keep well?

Suggestions for the Teacher

1. Frog's eggs, appearing like dozens of shot in a mass of jelly-like substance as large as one's fist, may be found during April in ponds, and used to show how cells multiply. If the lower half of the eggs are white, each is probably a single cell, and if they are kept in water, furrows will appear on the surface as the cells increase in number. The eggs may be preserved in a jar containing a half pint of water to which has been added a half of a teacupful of formaldehyde.

2. Secure a piece of transparent membrane just inside of the outer layer of an onion, and lay it in a drop of water on a piece of glass. By looking through it toward the light with a common magnifying glass, thousands of rectangular cells may be seen.

3. Slipper animalcules may be produced in abundance by placing in a glass of stagnant water some dry grass and any plant found growing in water. The glass should be kept for a week or more in a warm room. The animals appear as minute oval bodies in a drop of water placed on a glass slide and examined with a common magnifying glass. They are just visible to the naked eye.

III. COMPOSITION OF THE BODY

Water. — The body of a person weighing one hundred pounds contains in it about sixty-five pounds of water. If an ounce of beef is placed in a warm but not hot oven for a day, it will lose three fourths of its weight. This shows that the muscles of our body, which have about the same composition as lean beef, consist of only a fourth part solid material. Nearly nine tenths of the blood and one half of the bones are made of water.

Use of Water in the Body. — Without water the blood could not circulate through the tissues to carry food to them and bring away the waste products. Dry sugar will not go through a paper or membrane, but when dissolved in water it passes through readily. In the mouth, stomach, and intestines the water aids in softening and dissolving the food so it may pass into the blood. Muscles cannot contract without water, as they would be hard and fixed like a piece of dried beef. The passing off of water through the skin helps to keep the body cool. In fact, no organ could do its work without water, the amount of which taken in daily with food and as drink is about two quarts.

Solids. — One third of the body is composed of solid materials consisting chiefly of the following substances: 1. *mineral matter*, such as salt, soda, lime, and iron; 2. *proteids*, like the white of an egg; 3. *fats*, such as lard

and tallow; 4. *carbohydrates*, of which sugar and starch are good examples. The mineral matter makes up much of the bones, but in most other parts of the human structure proteids are present in the greatest abundance.

Mineral Matter. — This is the ashes left after burning a piece of wood or flesh. The mineral substances form about one half of a bone and are chiefly compounds of lime. More than a teacupful of common salt is distributed throughout the body. Iron in amount sufficient to make a piece as large as a cent occurs in the liver, blood, and hair. A few other mineral compounds are present in various organs, but no gold, silver, lead, or copper are constituents of the human structure. As minerals are constantly passing out of the body in the excretions, a new supply must be furnished by the food. Milk, meat, eggs, and vegetables contain all the mineral substances required by the body.

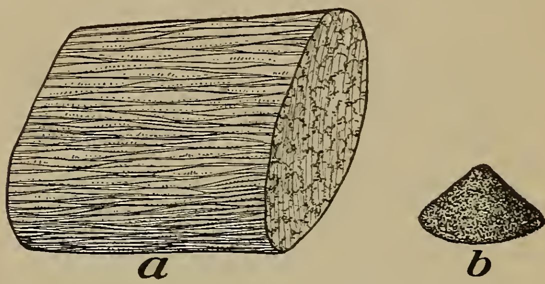


FIG. 11. — Mineral matter in muscle. *a*, piece of fresh muscle; *b*, the mineral matter remaining after the muscle was burned.

Proteids. — These make up four fifths of the solid part of the muscles and are present in all the tissues. The easiest form of proteid to observe is albumin which with water forms nearly all the white portion of a hen's egg, and is also the chief part of the protoplasm in the cells of the body. Albumin is so named because when heated to near the boiling point it becomes white, and it is then

changed from a fluid to a solid state. The change of a proteid from a liquid to a solid is called *coagulation.*

The clotting of blood is the coagulation of the proteid in the blood. The clabber of sour milk is the coagulated *casein* which is the proteid of milk. *Gluten*, the proteid of wheat, may be separated from the other parts of the flour by placing flour in a handkerchief or muslin bag, and kneading or squeezing it ten minutes in a pan of water. The sticky and stringy material left in the bag is the proteid.

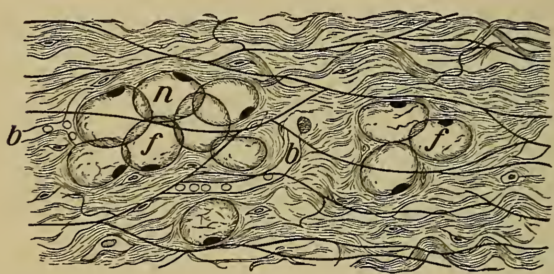


Fig. 12.—Fat cells in the connective tissue just under the skin. *b*, blood vessel; *f*, oil; *n*, nucleus. Magnified.

Fats. — Fats are found in nearly all parts of the body. They constitute nearly one tenth of the brain, one fifth of the nerves, while more than four fifths of the tissue called *adipose*, or fatty, is made of pure fats. The fat of the cow is known as *tallow*, and that of the hog *lard.* In the living body the heat keeps the fats in a liquid form. Fats which remain liquid at the temperature of a living room are called *oils.* Linseed oil, olive oil, and castor oil are examples of fats derived from plants.

To determine the presence of fat in a substance, place it on unglazed paper and warm it a few minutes. If fat is present, it will melt and soil the paper. The fat of the body is stored in cells so small that a bunch of fifty would be no larger than the head of a pin. Most of our fat is made from the sugars and starch eaten.

Properties of Fats. — Fats will not form a lasting mixture with water; but if the two liquids be shaken in the same bottle, the fat will in a few minutes rise to the top. If a few drops of ammonia or a piece of potash is added to the liquids before shaking, the fat is then broken up into tiny globules and will remain scattered throughout the mixture. This is called an *emulsion.*

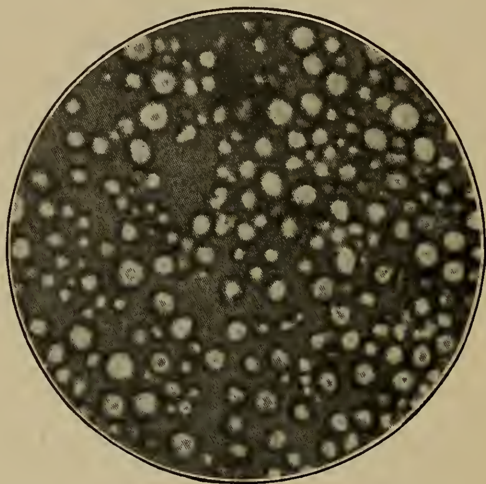


FIG. 13. — Part of a drop of cream photographed through the microscope to show the fat globules.

The fats eaten form an emulsion in the intestines before they pass into the blood. Milk is a natural emulsion, and therefore an easy food to digest. A drop of milk under the high power of the microscope will show over a thousand globules of fat. When milk stands a few hours, many of the globules rise to the top and form a layer of cream.

When any fat is heated with a solution of potash or soda and water, soap is formed. This process is called *saponification.* Glycerine is made at the same time.

Use of Fat. — The layer of fat just beneath the skin is from one tenth to five tenths of an inch thick and protects the body from the cold. The *living processes* going on in the body cause the fat to be changed into carbon dioxide and water. This change produces heat to warm the body just as burning a tallow candle makes heat.

Fat stored in the body can be used as food by the muscles, heart, and brain when one is not able to procure or eat food. A man named Tanner lived forty days without taking any food, and during this time he lost thirty-six pounds. Almost all of this was fat, but there was some loss from the other tissues. The fat surrounding some of the organs, such as the eye and kidney, is useful in protecting them from injury.

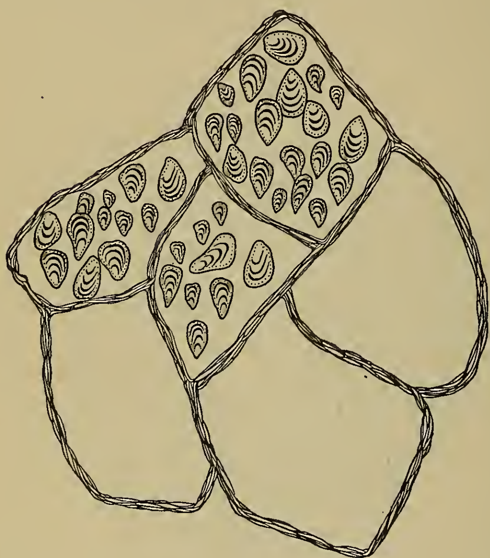


Fig. 14.—A tiny slice of potato showing three of the cells full of starch grains. Magnified.

Carbohydrates.—These are the *starches* and *sugars*. More than two thirds of the solid part of vegetable foods, such as corn, wheat, peas, and potatoes, consists of starch. It occurs in the form of little grains which may be seen by placing the scrapings of a potato under the microscope. Potato starch grains are somewhat egg-shaped, but corn-starch grains are more cubical. If starch is chewed in the mouth for several minutes, the saliva will change it into sugar. A great deal of starch is present in green fruit, such as apples, pears, and cherries, but when they become ripe, the starch is changed to sugar.

Use of Carbohydrates.—Starch and sugar, by means of the living cells, are changed into carbon dioxide and

water, and thereby give off heat. This helps to keep the body warm. At the same time, power to move the muscles is also furnished. The starch and sugar not used for these two purposes are changed into fat and stored up in the body.

Questions

1. How much of the body is composed of water? 2. How can you separate the water from a piece of beef? 3. In what way is water useful to the body? 4. Mention several kinds of solids present in the body. 5. Name some minerals in the body. 6. Where have you seen a proteid? 7. Describe coagulation. 8. Name three kinds of proteids and tell where each is found. 9. State some facts about fats. 10. How do you learn whether fat is present in a substance? 11. How is soap formed? 12. Of what use is fat? 13. In what foods are carbohydrates found? 14. Of what use are carbohydrates? 15. Why should more carbohydrates and fats be eaten in winter than in summer? 16. Should a banker eat the same kind of food as a blacksmith? Why?

Suggestions for the Teacher

1. Light a match and let it burn up completely to show the mineral matter remaining.

2. To show coagulation let some milk stand in a glass in a warm room one or two days, or pour a teaspoonful of vinegar into the milk.

3. Place a little of the white of egg in boiling water and note the coagulation.

4. Exhibit some lard, tallow, and castor oil and warm the first two in a cup, to show that the fat of the body is in a fluid condition.

5. Put a tablespoonful of water in a bottle or test tube and add a few drops of castor oil. Then shake and observe how soon the water and oil separate. Now add twice as much ammonia as you did oil and shake again. Note that a permanent emulsion results.

IV. LIFE PROCESSES

How Dead and Living Bodies Differ. — Every object in the universe is either dead or alive. Movement is not a sure sign of life. A trolley car and a locomotive move, as do also the earth and the other planets, yet they are dead bodies. Some living bodies, such as a blade of grass, a flower, or a tree, have no motion in themselves, but they may be swayed by the wind. Living bodies are able to grow and change their form and size by taking within them lifeless material of certain kinds, and by transforming it into a part of themselves. No dead body can absorb material from the soil, as does a tree, and change it into the substance of its own body. A nestling bird makes bones, flesh, and feathers of the thousands of insects brought by the mother.

The Change from Dust to Man. — Animals and plants grow only when they obtain food such as can be built into their bodies. Plants feed on substances in the earth, such as potash, saltpeter, limestone, and gypsum, but much of their food is the carbon dioxide of the air. Animals cannot use any of these simple substances, but must consume vegetables or animal flesh to nourish them. Grass is only a portion of the air and earth made over into a new form by sunlight and the action of the tiny sprout from the grass seed. Some of this grass carried into the cells of the cow's body becomes beef, which, eaten by man,

becomes a part of a human being. Thus indirectly man's flesh is made of the air and the dust of the ground.

When death claims the grass, cow, and man, their bodies crumble again to dust and make up part of the earth. The crumbling, or decay, is produced by molds and millions of other tiny plants called bacteria. In this way the dead hay or straw, acted on by these agents, may appear the next season in the form of a field of waving grain. This, when ground into flour by the mills, becomes, upon being eaten by man, a part of the human race.

FIG. 15. — Bacteria which change dead matter into a food for plants. Magnified.

Kinds of Compounds. — The three common classes of compounds are *acids*, *alkalies*, and *salts*. Acids are sour and turn blue litmus paper red. Alkalies are not sour and will turn red litmus paper blue. Sulphuric acid, vinegar, and sour milk are examples of acids. Potash, soda, and ammonia are alkalies. Table salt and limestone are salts.

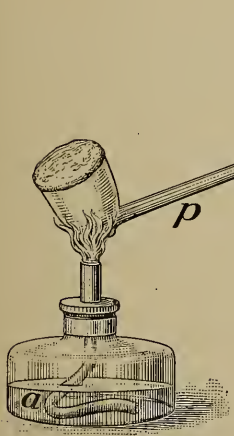


FIG. 16. — Separating wood into gas and charcoal. *p*, clay pipe containing bits of shavings and covered with mud; *a*, alcohol lamp; *l*, flame made by the gas lit as it issued from the stem.

Elements of Life. — The elements most abundant in a living body are carbon, hydrogen, oxygen, and nitrogen. *Carbon* composes half of the solid part of

lean meat, more than half of a stick of dry wood, and is plentiful in nearly all foods eaten. Carbon is the chief solid element in muscles, fat, sugars, starches, and wood. The other abundant elements are gases. If, therefore, some bits of wood be heated very hot in a clay pipe while the top of the bowl is covered with wet clay to keep out the air, the gases will go out through the stem, and as they issue may be lighted with a match. After fifteen minutes' heating, carbon, called charcoal, is left in the pipe. In a similar way gas for lighting houses was formerly made by heating soft coal in iron boxes.

Fig. 17. — Making hydrogen. The bottle contains five nails and weak sulphuric acid. To the right of the flame of hydrogen at the tip of the glass tube are two drops of water formed by the union of the hydrogen coming out of the bottle and the oxygen in the air.

Hydrogen. — This is present in nearly all foods and composes two thirds of water. It is a colorless gas, and may be easily made by pouring some weak sulphuric acid into a bottle containing a few nails or tacks. The iron pushes off the hydrogen, which forms part of the acid, and the gas appears in bubbles (Fig. 17). It will pass out of a glass tube inserted through the cork, and will burn when a flame is applied to it. This burning is the union of the hydrogen with the oxygen of the air. As a result water made of hydrogen and oxygen is formed. This appears in drops on a bottle held upside down at the top of the flame.

Oxygen. — This is a colorless and odorless gas which constitutes one fifth of the air, one third of the water, and about one fifth of the solid portion of all living things. Many lifeless compounds contain it.

Oxygen may easily be prepared by heating together in a test tube black oxide of manganese and chlorate of potash. To catch the gas, arrange a bent glass tube with its one end through the cork in the test tube and the other passing just within the mouth of a bottle filled with water and turned upside down in a dish of water (Fig. 18). The bottle is filled with water at first to expel the air.

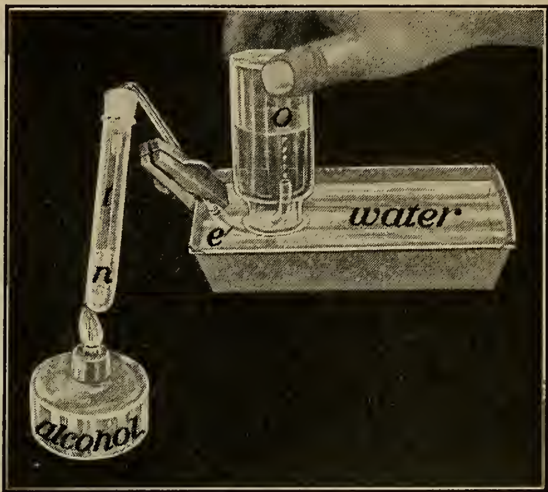


FIG. 18. — Making oxygen. *e*, rubber tube; *n*, chlorate of potash and black oxide of manganese; *o*, oxygen which is bubbling out from *t*, the test tube.

Properties of Oxygen. — Oxygen is the most important of all the elements, and is absolutely necessary for the life of animals. No fire can burn without it. It differs from the other elements in the fact that it may be made to join itself to nearly all the elements. Iron exposed to the air rusts. The rust is the union of iron and oxygen, and is called iron oxide. Carbon, when heated, unites with oxygen to form carbon dioxide.

When oxygen combines with any substance, the process is named *oxidation*. The substance with which the

oxygen unites is said to be *oxidized*. Burning a match means oxidizing the wood. Any piece of timber lying out-of-doors slowly rots. This is slow oxidation. The oxygen of the air is made to combine with the wood by means of very tiny plants called bacteria. These cannot grow unless some moisture is present. Oxidation produced by living cells of the body is constantly going on within every plant and animal, and without this process life cannot continue.

FIG. 19. — A match being oxidized.

FIG. 20. — Roots of red clover with swellings which are the home of bacteria enabling the plant to feed on the nitrogen of the air.

Oxidation in the Body. — The oxygen of the air is received through the nose and windpipe into the lungs. Here it passes into the blood, and is then carried to every cell in the body, where living action causes it to unite with the tissues or the food present. As a result heat is slowly produced,

just as when the match was quickly oxidized by lighting it. Oxidation also produces *energy*, which makes the muscles move the body and the other organs do their work. When running or working hard, we breathe very fast in order to get enough oxygen to make the muscles do their work. To make the fire burn faster, the draft must be opened below to send the air containing oxygen into the stove so it may oxidize the wood. The heat thus produced may be made to boil water and change it into steam, which can be transformed into power to run an engine.

Nitrogen. — This constitutes four fifths of the air and forms an important part of most of the tissues of the body. It is one of the chief elements in the food of plants and animals. Any substance, such as skim-milk cheese, containing a large amount of it is called *nitrogenous material.* No animals can make direct use of the nitrogen of the air, but some plants, such as clover, beans, and peas, are able to get it from the air and use it for food by the assistance of bacteria growing on their roots and forming little swellings like the head of a pin.

Questions

1. Give two differences between a dead body and a living body. 2. How are we able to use air and soil for food? 3. What changes dead leaves and wood to dust or earth? 4. Name five elements. 5. How does an element differ from a compound? 6. Name three kinds of compounds. 7. How does an alkali differ from an acid? 8. What four elements are most abundant in man? 9. How can you make carbon? 10. Describe the preparation of hydrogen. 11. Explain oxidation. 12. Why are the drafts of a stove opened below to make the fire burn? 13. Why do we breathe faster when at hard work? 14. Where is nitrogen found? 15. Why must one eat some nitrogenous food?

Suggestions for the Teacher

1. Fill the bowl of a clay pipe with wood shavings and cover over the top with wet clay or mud. Heat over a hot flame, and in five minutes the gas issuing from the stem inclined upward may be lit. When the gas which is formed from the carbon and hydrogen of the wood ceases to burn, carbon will remain in the bowl of the pipe.

2. Place in a small bottle water to the depth of two inches and add a half inch of sulphuric acid. Prepare a tight-fitting cork containing a hole, through which is thrust a small glass tube. Drop into the bottle a dozen tacks or nails, then insert the cork, and after five minutes, try lighting the colorless gas coming from the tube. Use a long splinter and stand off about two feet from the bottle to avoid any accident that might possibly occur. Do not let acids drop upon the clothing or the hands.

3. Hold a vial over the flame formed in experiment 2 and note the water forming on the glass. Explain.

4. Ask one of the pupils to secure the roots of a clover, bean, or pea plant growing in loose soil. After it is washed, let him show in class the swellings or tubercles produced by the growth of bacteria taking nitrogen from the air.

V. FOOD AND ITS USES

Need of Food. — Food is required to replace dying parts and to furnish heat and energy. The weight of a boy after taking part in a game of football, or other vigorous exercise, during which no water or food has been taken, will be several ounces less than before the play; but in the same period the weight of the boy who sat quietly and watched the game will show almost no decrease. This shows that the muscles wear out by use. Some of the worn-out parts pass off in the sweat and breath. The temperature of the body is the same in both cold and warm weather. This shows that material is being burned inside of it to produce heat. Food must therefore be supplied to replace what is burned up to keep the body warm.

Kinds of Foods. — The term *food* includes everything that is consumed for the purpose of nourishing the body or supplying it with heat and energy. The five chief *food stuffs*, or *proximate principles*, are *mineral salts*, *water*, *proteids*, *fats*, *carbohydrates*. All these substances except either carbohydrates or fats are absolutely necessary to maintain the body in health. Proteids serve to replace dying particles of tissues. As both the carbohydrates and fats are used largely for furnishing heat and energy, either one may be dispensed with, provided an extra supply of the other is used.

Mineral Salts and Water. — These are necessary for

the proper nourishment of the body. A little common salt is present in all meat, but to make it palatable, more is usually added. The salts of potash, lime, and iron are present in many vegetables and fruits. Dr. Forster fed dogs with food from which all the salt had been extracted, and as a result they died in about one month. An adult takes daily with his food about as much table salt as can be held on a large tablespoon. *Lime salts* are especially necessary in the young to help build the bones. *Iron salts* are constantly needed to form an important part of the red blood corpuscles.

Water is a carrier of the foods through the body and an aid to the organs in performing their functions. More than half of most foods consists of water.

Proteids. — The white of egg is composed of water and albumin, which is one of the commonest forms of proteid. Lean beef is made almost entirely of proteid and water. Skim-milk cheese consists of nearly one third proteid and two thirds water. Proteids form a part of every cell in all plants and animals.

Heating a proteid or adding to it either alcohol or nitric acid usually causes it to coagulate, that is, form a tough, jellylike mass similar to the boiled white of egg. The proteid part of food keeps the tissues of the body in repair. If more proteid is eaten than is necessary to rebuild the worn-out part of the machine, it may be transformed into fat and may also provide heat and energy by becoming oxidized.

Carbohydrates. — *Sugar* and *starch* are nearly pure carbohydrates. Starch, which occurs abundantly in most vegetable foods, is the source from which the body derives

nearly all its carbohydrate materials. More than half of wheat bread, dried peas, beans, and corn consists of carbohydrates, and more than three fourths of wheat flour and rice is made of carbohydrates. Meat contains almost no carbohydrate material, and eggs none whatever. Carbohydrates furnish most of the energy of the body and some heat. When eaten in large quantities, they tend to make a person fat.

Fats. — Fat occurs in most animal foods. Butter is the kind of fat present in milk. Cream cheese is nearly one third fat, and eggs about one eighth fat. The fats extracted from plants are often called *oils*. Such are cottonseed oil, linseed oil, and castor oil. Very little fat is present in most vegetable foods. Fat eaten and taken to the tissues is made to unite with oxygen received into the blood from the lungs, and by this union heat is produced. The consumption of more fat than the body needs may cause one to become fat.

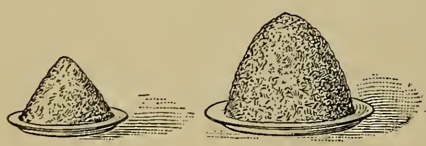
Condiments and Flavors. — Pepper, salt, vanilla, cinnamon, nutmeg, vinegar, and mustard are called *condiments*, or *flavors*. They are generally added for the purpose of making food more appetizing. The pleasant odors and spicy tastes increase the flow of the digestive juices, and in that way aid digestion and so increase the real value of the food eaten. Too much of the condiments, especially pepper, vinegar, and mustard, may have an unwholesome effect on the cells of the stomach and some of the other organs.

Stimulants. — Tea, coffee, cocoa, chocolate, beef tea, and alcoholic drinks are called *stimulants* because sometimes they hasten the action of certain organs. They are all dis-

cussed in a later chapter, with the exception of *beef tea.* This contains very little nourishment, but is of great value in setting the digestive glands to work, and thus preparing for the true food which should follow later. The use of much beef tea is harmful.

There is a dispute as to whether *alcohol* is really a food. Whether a food or not, there is danger in using it, owing to the fact that many thousands yearly acquire an alcohol thirst which causes much ill health and many untimely deaths. The Harveian Society has shown that one seventh of the deaths of adults in London are due to alcoholic drink. Numerous experiments and observations made by business men and scientists prove that alcoholic drinks, such as beer, whisky, and wine, form the greatest single factor in the making of criminals and paupers in this country.

Food Values. — The real value of food does not depend upon the amount eaten but upon how much is digested and carried from the alimentary canal into the tissues of the body. Food has two kinds of value: a *tissue value* and a *fuel value.* Proteids, such as lean meat and skim milk, have largely a tissue value because they can be used in building up the parts of the cells and tissues being worn out. Sugars, fats, and starches have a large fuel value because they unite with oxygen in the body and produce heat, muscular movement, and activity of the



a *b*

FIG. 21. — Heat-making power of food. *a*, amount of fat required to make one calorie or heat unit; *b*, quantity of sugar or pure proteid necessary to produce one calorie.

organs. The fuel value is reckoned in *heat units.* Experiments show that food burned outside of the body gives off the same quantity of heat as when oxidized, or burned by the living cells in the body.

Amount of Food Needed. — Most people eat too much of one kind of food, such as meat or sweets. No one can live on sugar and fat alone longer than a few weeks, because

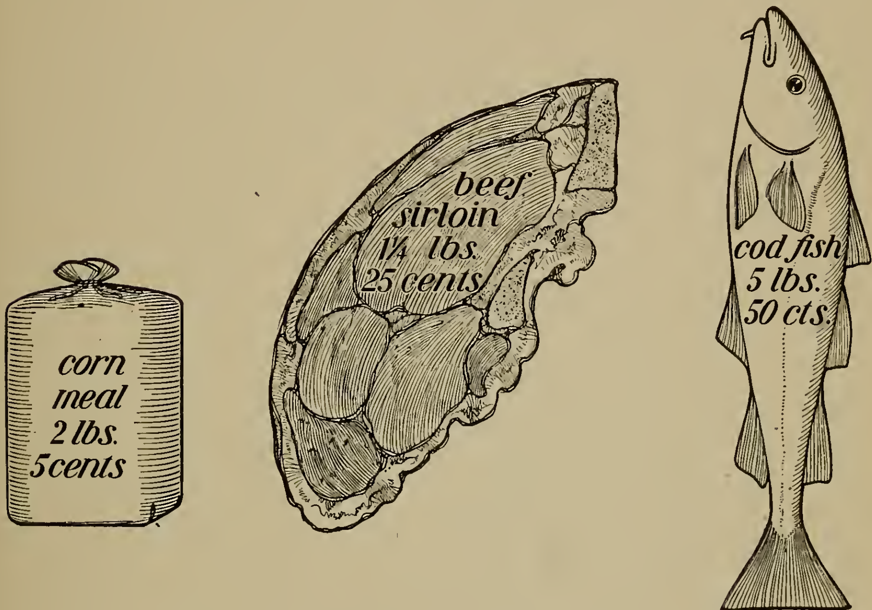


Fig. 22. — Diagram showing the difference in cost of three foods each of which furnishes about the same amount of nourishment.

these substances have no tissue value and cannot rebuild the worn-out cells. They have only a fuel value, giving heat and energy. A man at hard labor needs much more fats and starches as fuel to furnish energy than one who is idle. Experiments on hundreds of persons show that the average man should have *daily food* containing one eighth of a pound of pure proteid for the tissues, and

there should also be fats and starches to furnish a fuel value of 3000 heat units. A woman needs about one fifth less. To select food with the proper fuel and tissue value, one must know of what certain meats and vegetables are composed.

Diet. — Diet is a course of food selected with reference to health. A knowledge of diet is important not only because it enables one with a small amount of money to select the most suitable fare, but because a proper diet does much in preventing sickness and in helping the sick to get well. Recent studies have shown that if the proper attention were given to the tissue and fuel value of food, the people of this country could purchase the same amount of nourishment as they now take for $500,000,000 less annually than the present cost.

In some institutions of learning where the average price of board is three dollars per week, the boys anxious to economize have been known to board themselves in their room at a cost of only seventy-five cents per week. The daily fare generally consisted of one quart of milk, some fruit, and sufficient bread and oatmeal to satisfy the appetite. These foods are rich in proteid and have a large fuel value.

Oysters, fish, and beef sirloin are expensive foods. Skim milk, potatoes, oatmeal, wheat bread, and corn mush are cheap foods that furnish the necessary nourishment. The table on the following page (Fig. 23) shows that ten cents' worth of corn meal contains five times as much proteid and has ten times as much fuel value as ten cents' worth of beef sirloin.

In *sickness* the diet is more important than medicine.

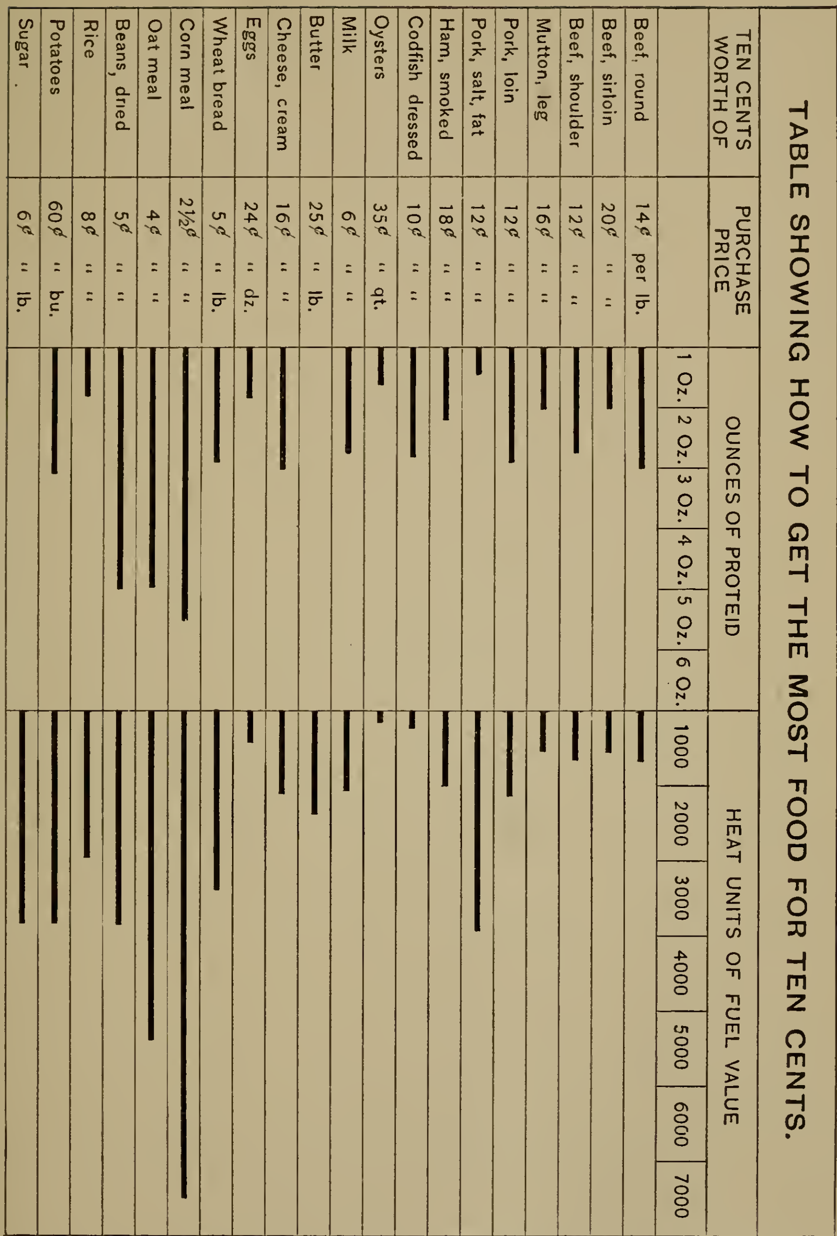


FIG. 23. TABLE OF FOOD VALUES.

The recovery from dyspepsia, typhoid fever, tuberculosis, and all bowel troubles depends largely upon the diet of the patient. Constipation, or clogging of the large intestine, and appendicitis, sometimes resulting from it, may be avoided in many cases by choosing a diet from such foods as corn-meal mush, bread from whole wheat, dried and fresh fruits, rhubarb, onions, tomatoes, peas, beets, spinach, liver, and wild game. Much water should also be taken. Hot bread, crackers, pastry, cake, dried and smoked meats, cheese, boiled milk, tea, potatoes, and rice should seldom be eaten by one troubled with constipation.

It is said that Germany owed her success in the Franco-Prussian War to diet. The disease of beriberi, once so common in the Japanese army, was held in check by using certain foods and avoiding others. Scurvy, so prevalent among the sailors and explorers years ago, now seldom occurs because more vegetables and less dried and salt meats are used.

Fruits. — Most fruits contain a large percentage of water and only a small amount of the food elements. However, they form a very important part of the diet because of their agreeable flavor, which increases the flow of the digestive juices, helping in the digestion of the other foods. They aid much in stimulating in a healthy way the activity of the digestive organs, which otherwise may become sluggish and then be harmed by the careless use of pills or other drugs. Ripe fruits also furnish some of the mineral foods. Overripe fruit and unripe fruit should never be used.

Adulteration of Foods. — A food is said to be adulterated when a cheaper material is mixed with it or some

chemical is employed to preserve it. Alum is sometimes added to wheat flour to increase the whiteness. Wheat flour, gypsum, clay, and radish seeds are often present in prepared mustard. Ground corn, rice, buckwheat hulls, cocoanut shells, crushed olive stones, and sawdust are frequent adulterants of pepper. Coffee is occasionally adulterated with the ground-up root of the chicory plant. Olive oil sometimes contains large quantities of cottonseed and peanut oils. Milk is frequently diluted with water.

Of 8651 samples of food examined in Massachusetts in 1904, over twenty-six per cent was found to be adulterated. As only those foods thought to be of poor quality were selected, it is probable that the actual proportion of adulterated foods in the market is much less. The recently enacted pure food laws and the appointment of inspectors are doing much to lessen the sale of impure foods.

Special Foods. — The breakfast foods which are sold cooked and ready for the table are pure and wholesome, as most of them are made from steamed and crushed wheat, oats, or corn. For nourishment, well-cooked oatmeal is equal to them, is much cheaper, and is quite as palatable when mixed with a few chopped dates, figs, or bananas.

Renovated butter, made by purifying a rancid or poor quality of butter, is sold at a lower price than genuine butter, but contains about the same food value. *Butterine* and *oleomargarine*, of which 70,000,000 pounds are sold yearly, are made from tallow, lard, cottonseed oil, and cream. They are good foods, but are not worth so much as butter. Fruits, vegetables, and meats put up in cans

are usually wholesome, but it is preferable to use the fresh articles when they can be obtained.

Cooking. — Foods are cooked for three purposes: to render them more easily digestible, to develop the flavors, and to kill the germs of disease which occasionally may be present. Meats are most healthful when baked, roasted, boiled, or broiled. To boil meats and vegetables, they should be at the first immersed in boiling water to coagulate the surface layer, and thus prevent the escape of the nourishment. In making stews and soups, the meat and vegetables should be put into cold water and slowly heated to near the boiling point. In this way the water draws out the flavors and nourishment to form delicious soup. Old bread and toasted bread are much more easily digested than that newly baked. Fried foods often cause indigestion.

Hard-boiled eggs are not so easily digested as those partially cooked. A good method of preparing eggs for the table is to put them in a pan off the stove and pour on sufficient boiling water to cover them one inch deep. In fifteen or twenty minutes the white will be in a creamy state easy to digest, and the yolk will also be well cooked, but not hard. Eggs thus cooked are easily digested by invalids and year-old children.

To cook food so that it shall be highly nutritious and delicious, is an art which every girl ought to acquire. Poorly cooked food causes ill temper, ill health, and unhappiness. The dry and insipid bread often bought at the store or bakery should not replace the appetizing homemade article. The girl who knows how to prepare a dainty meal and serve it with a pleasant smile is sunshine

in any home. The boys who obtain the greatest profit and pleasure from camping know how to cook.

Questions

1. What is a food? 2. Which of the food stuffs are necessary to life? 3. Where do proteids occur? 4. What foods contain much carbohydrate? 5. Mention a food containing no carbohydrate. 6. Name several kinds of fats. 7. What is the effect in some cases of eating much fat and carbohydrates? 8. What evidence can you give showing that some mineral salts are necessary for health? 9. How much water does a man take into his body daily? 10. Which of the condiments may harm the system? 11. What are stimulants? 12. Give three reasons why alcoholic drinks should not be used. 13. What two kinds of value has food? 14. How does food keep the body warm? 15. How much food does an average man need daily? 16. Explain why five cents' worth of corn meal is of more value as a food than twenty-five cents' worth of sirloin. 17. Show that five cents' worth of oatmeal has as much food value as twenty-five cents' worth of mutton leg. 18. Why is ten cents' worth of beans equal in food value to a dollar's worth of oysters? 19. Of what importance is diet in sickness? 20. Describe renovated butter, butterine, and oleomargarine.

Suggestions for the Teacher

1. Ask a pupil to weigh a peeled apple, and after drying it in the oven a day or two, to weigh it again. Request another pupil to do the same with a potato. Calculate what part of these foods is water.

2. Ask several of the pupils to try cooking eggs at home so that the yolk may be made palatable and yet the white remain like a thick cream instead of being rendered hard and tough.

VI. MICROBES AND MOLDS

The Ancient Belief as to the Origin of Life. — Until the middle of the last century, people generally believed in what is known as *spontaneous generation*. This is the changing of dead particles of matter into living forms without the aid of any other life. Aristotle said over 2000 years ago that some animals spring from putrid matter, certain insects come from dew, threadworms originate in the mud of wells, and lice proceed from the flesh of other creatures. Even to-day some people believe that the maggots, or little wormlike animals found on meat in warm weather, have come from the meat. The fact is that the maggots result from the hatching of the eggs of flies which were laid on the meat.

Fig. 24. — Bacteria that cause meat to spoil. Magnified.

If flies are kept away from meat in warm weather by netting, it will nevertheless spoil. The microscope shows that the spoiling is due to millions of tiny plants now called *bacteria*.

Discovery of the Cause of the spoiling of Food. — Milk or meat broth standing exposed a day or two in warm weather begins to decay. In it are formed great numbers of bacteria which until forty years ago were thought by many to be particles of the milk or broth changed to life by spontaneous generation. Tyndall, Pasteur, and others have shown that the bacteria came from the growth of

other bacteria always found floating in the air. This was proved by placing some broth in several jars, some of which, after being boiled to kill all life, were tightly sealed, while the others were left open. In a few days all of those remaining open were found to contain numerous tiny living

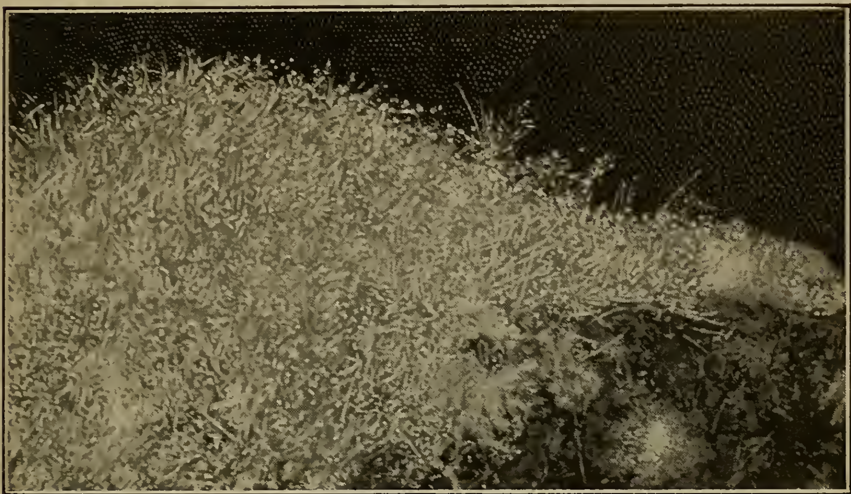


FIG. 25. — Mold growing on bread. The little knobs on the top of some of the threads contain hundreds of tiny round bodies called spores or germs. These break loose and being blown about get on food and cause another growth of mold.

and moving bodies. Even after weeks the sealed jars contained no life.

The Nature of Bacteria. — Bacteria are one-celled plants. They are often called *microbes* or *germs*. Minute one-celled animals are also called microbes or germs. A piece of mold is sometimes spoken of as a germ. *Molds* differ from bacteria in being much larger, forming long threads, and not dividing in the middle to produce new plants. Some molds are useful in giving flavor to cheese, others cause decay in any vegetable or animal material on which they grow, and

a few kinds may produce disease, such as ringworm and barber's itch.

Over 1000 different kinds of bacteria are now known, but it is impossible, except in a few cases, to distinguish one kind from another by merely examining them with the microscope, because several different varieties have exactly the same shape. There are three general forms: the spherical ones, named *cocci;* the rodlike, known as *bacilli;* and the curved ones, called *spirilla.* The bacilli are the most common forms, but the spirilla are the largest, some of them in stagnant water being easily seen under a microscope magnifying only 100 diameters.

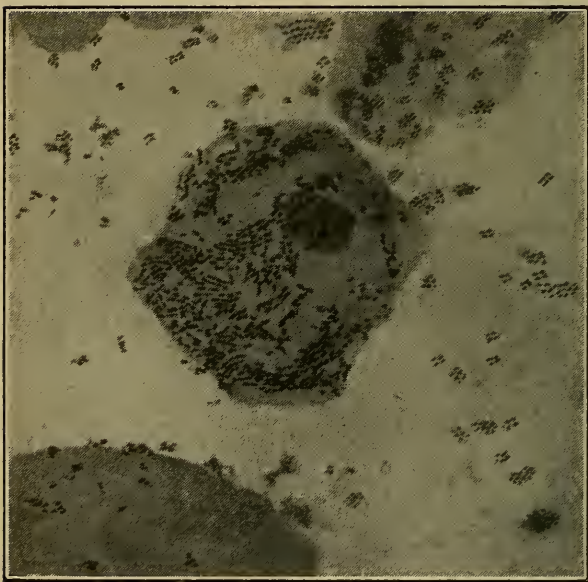


Fig. 26. — This flat cell, having on its surface over 200 bacteria, is from the mouth of a well person. Thousands of such cells with bacteria are present in all mouths. Photographed through a microscope.

Bacteria are abundant in milk, water, soil, and air. A bit of rich earth as large as a pea may contain over 5,000,000. The usual water often consumed in one drink contains more than 50,000, and a glass of good buttermilk has in it millions of bacteria. Vast numbers live on the surface of the body, and millions dwell in the alimen-

tary canal, while still others are being blown about in the air. When the air is quiet, they settle down and stick fast on all moist surfaces. Most bacteria are harmless to man when taken into the nose or stomach. A few kinds produce disease, and some others are of great use in nature.

How Bacteria grow and Multiply. — With favorable surroundings, such as warmth, moisture, and food, bacteria increase rapidly in numbers. Their method of growth is to lengthen out slightly and then to divide crosswise into two equal parts. A germ can divide every half hour so that one plant might produce many millions of descendants in one day. Most of them can live for months in a dry state, and some can remain alive all winter in a cake of ice. Certain kinds are able, when food fails, to surround a portion of their living material with a thick, protecting coat, and thus form a spore (Fig. 28). The spores of some germs may be boiled over twenty minutes without killing them. Fortunately none of our common disease-producing bacteria can form spores, and they are therefore easily killed by heat.

Fig. 27. — Diagram showing how bacteria divide to form new bacteria.

Fig. 28. — Bacteria, four of which contain spores.

Bacteria and Disease. — Only about twenty different kinds of bacteria produce disease in man. Diseases caused by germs are known as *infectious diseases* because the germ infects or makes its way into the body. *Bacillus tuberculosis* causes consumption, scrofula, and white swelling. The *diphtheria bacilli*, growing in the throat, produce

diphtheria. Pneumonia, sore throat, and colds occur when certain bacteria are present in great numbers. Whether disease-producing bacteria, after gaining entrance to the body, shall cause disease or not, depends upon the ability of the tissues to destroy them.

FIG. 29. — Germs that cause tuberculosis or consumption growing in clusters appearing as white spots on a piece of potato smeared with glycerine.

How Bacteria produce Disease. — Bacteria must get into the tissues and multiply in order to cause disease. They may find entrance through the alimentary canal, the lungs, or the skin. Germs like those of tuberculosis and typhoid fever may reach the intestine with food or water, and penetrate the cells there, and even pass through the walls of the intestine into the blood to be carried to any part of the body. Throwing dead animals or waste matter into a stream of water is a crime, because the bacteria in them may cause disease and death to persons living along the stream and using the water for drinking. With the air, bacteria enter the lungs when some of the ciliated cells lining the air tubes are injured. A break in the skin or even a faulty skin gland may permit bacteria to reach the tissues beneath and produce a running sore; or blood poison may result

if they are carried through the system. Knives, needles, and dressings used in any operation, such as removing a splinter, or vaccination, should first be boiled to kill the germs on them.

FIG. 30. — Bacteria that cause boils. Magnified.

Bacteria injure the body in two ways. They consume the tissue, and they give off poisons. The bacteria causing boils eat away the tissues so as to form little holes, but they do not give off much poison. The diphtheria bacilli do not destroy much tissue, but excrete a great deal of poison, affecting the heart and other organs.

FIG. 31. — Bacteria that cause milk to sour. Magnified.

The Useful Bacteria. — The souring of cream for churning, the flavor of some cheese, the manufacture of linen, the making of vinegar, and the fertility of the soil depend upon different groups of bacteria. The action produced by bacteria on any substance is known as *fermentation*. The cider by means of yeast always present on fruit is fermented to form a weak alcohol, and then certain bacteria by fermentation change the alcohol to vinegar.

FIG. 32. — Plants that cause fermentation. *a*, yeast plants which change cider partly to alcohol; *b*, bacteria which change the alcohol to vinegar.

Straw, hay, and the bodies of dead animals cannot decay without bacteria. This *decay* is absolutely necessary before dead material can become food for the green plants. If there were no bacteria to rot waste matter and thus fertilize the soil, the plants would soon use up all the

nourishment in the ground and die. The animals would then have no food, and their death must result, and man would follow the same fate. It is evident, therefore, that this world is saved from becoming a dreary waste by the action of tiny bacteria.

The Preserving of Food. — Since intense cold prevents the growth of bacteria and molds, foods are put in ice houses and refrigerators to prevent spoiling. Meat at freezing temperature may be preserved for years. Some meats, such as smoked ham and dried beef, have been soaked in a salt solution several weeks or well rubbed with salt, and then smoked and dried on the surface. This keeps out the bacteria, and the salt restrains greatly the growth of bacteria and molds.

Fruits and vegetables are heated to kill the germs and then sealed up tight in cans. Even then mold often grows on top of the food in the can because the lid and can were not kept in boiling water the ten minutes necessary to kill the spores of mold. The best plan in canning food is to put it into the jars and then cook it by placing the filled jars with the covers screwed on loosely in the oven or in a wash boiler on top of the stove. If the boiler is used, an inch or more of water and a cloth to prevent breakage must be put in the bottom.

The occasional poisoning resulting from the use of canned fish or meat is due to bacteria which were not killed in the cooking. They grew and excreted a poison called *ptomaine* in the can. Cooking does not affect this poison already formed, and boiling spoiled products does not make them safe for eating. Food should never remain in a metal can after it has been once opened.

Eggs may be preserved in a good condition for a period of about five months by immersing them in a tin or stone jar or wooden keg of dilute soluble glass (silicate of sodium). The pure soluble glass may be purchased at the drug store. The dilute soluble glass is made by adding one quart of pure soluble glass to ten quarts of water.

Questions

1. What did the ancients believe as to the origin of life? 2. How was the cause of the spoiling of food discovered? 3. How do molds differ from bacteria? 4. Where are bacteria found and how numerous are they? 5. About how many bacteria are required to make a mass as large as the head of a pin? 6. How rapidly do bacteria multiply? 7. What proves that bacteria can endure severe cold and heat? 8. Name some diseases due to bacteria. 9. How may bacteria get into the body? 10. How do bacteria injure the body? 11. Of what use are bacteria to the fruit and dairy industries? 12. Why could not life continue to exist without the aid of bacteria? 13. What prevents bacteria from destroying food? 14. How may the housekeeper prevent mold from growing on her canned fruit? 15. Why do canned meats occasionally poison people?

Suggestions for the Teacher

1. Moisten well some bread and then touch it to the floor in a few places to get the spores or germs of mold. Place in a tightly covered bowl in a warm room, and observe in from three to six days the threadlike growth of mold on the surface of the bread and erect branches bearing at their ends knobs which contain spores.

2. Colonies or groups of bacteria may be secured as follows: Ask several of the pupils to boil a potato a half hour, and then cut it into halves with a knife cleaned in boiling water. Stand each half in a cup containing about a spoonful of water. Set the cups in a room being swept for a minute or two, and then cover with a saucer tightly and keep in a warm room about a week. Note the white and yellow slimy spots which are colonies or clusters of bacteria produced wherever a single germ fell.

VII. MILK

Why a Knowledge of Milk is Important. — Milk forms the greater part of the food of every individual during the first year of life, and is often the chief nourishment for invalids. Nearly all of the thousands of patients now recovering from tuberculosis are using from one to three quarts of milk daily. A recent circular of the State Board of Health of New Jersey says: "The most important element in the enormous saving of child life, which is now occurring, consists in a better understanding of the dangers attending the use of unclean milk."

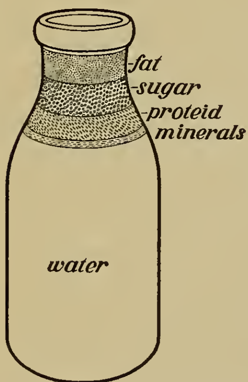


Fig. 33. — Diagram of a bottle of milk, showing of what it is composed.

Professor Sedgwick, a leading sanitarian, says: "Among all the vehicles of infectious disease there is perhaps none more dangerous than milk." The United States Census and Health Reports show that 50,000 children under five years of age died from the use of unclean milk during the years 1900–1904. Many other children, as well as adults, were made sick by the use of milk handled in a careless way.

Composition. — Cow's milk contains all five kinds of food stuffs. It consists of 87 parts of water, 4 parts of proteids, $4\frac{1}{2}$ parts of carbohydrates, $3\frac{2}{3}$ parts of fats, and

$\frac{5}{6}$ part of mineral matter. The chief proteid of milk is *casein*, which is coagulated into a jellylike mass called curd when milk becomes sour. The fat is in the form of minute globules two or three thousand of which are required to make a piece of butter as large as a pin head. The carbohydrate is *milk sugar*, much used by druggists in making pills. The most important of the several minerals in milk is lime.

FIG. 34. — Portrait of a boy who has never taken any other food than milk.

Food Value. — Milk is the only single article of food that contains all the elements necessary to the growth of the body. It is a perfect food, however, only for the very young, as the substances required for nourishing the adult are not present in the right proportions. Since cow's milk is quite different in composition from human milk, water, cream, and sugar are usually added to it when it is to be used for infants.

It would require about one gallon of milk daily to furnish a workingman the necessary amount of tissue-repairing substance, but the fats and sugars would not be sufficient to give the required heat and energy. Milk combined with bread and potatoes makes a diet enabling men to perform the heaviest work. A quart of milk contains the same amount of nourishment as three fourths of a pound of

beef. Milk surpasses many foods in real nourishing value not only because it contains more nutrition, but also because it is almost completely digested and absorbed, whereas from one tenth to one fourth of some vegetables consumed remain undigested.

Fig. 35. — A bottle of very sour milk (photographed), showing what it consists of. After Swithenbank and Newman.

Economy in using Milk. — Milk, at six cents per quart, forms a cheap nourishment when used with other foods, at the rate of one quart per day. An ordinary restaurant lunch of soup, beef, potatoes, turnips, bread, butter, and coffee, costing fifty cents, will furnish no more nutrition than a dairy lunch consisting of a half loaf of bread and a pint of skim milk, costing five cents.

A pound of sirloin steak, costing twenty cents, contains about the same amount of tissue builder as two quarts of milk, costing twelve cents, but the meat has only two thirds of the fuel value of the milk.

Skim Milk. — When milk is allowed to remain undisturbed in a vessel for several hours, much of the cream, containing the fat, rises to the top and may be removed. The fluid left is called *skim milk*. It contains the same nutriment as whole milk except the fat, which is diminished from three fourths to nine tenths. Skim milk is

therefore an excellent food, as it contains much proteid for tissue building and considerable sugar for fuel value. Two and a half quarts of skim milk have the same food value as a pound of the best lean beef. Two quarts of skim milk, costing six or eight cents, contain more nourishment than a quart of oysters, costing forty or fifty cents.

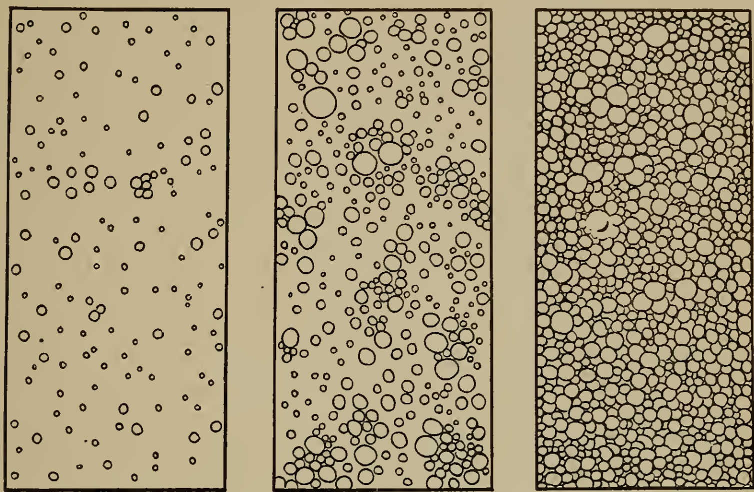


FIG. 36. — Globules of fat in skim milk, milk, and cream, as seen through the microscope.

About one tenth of skim milk is composed of solids which have all the value of whole milk for making blood, muscles, and bones, but only half the fuel value.

Buttermilk is soured milk from which the fat globules have been removed after being collected by churning into large masses called *butter*. Butter milk contains about the same nutriment as skim milk. As a food for calves and pigs it is worth at least one cent per quart.

Cream. — About one sixth part of milk consists of cream, which rises to the top when a vessel of fresh milk is let stand a few hours. It is formed of fine globules of

fat with some milk entangled among them. Cream contains less muscle-building substance than skim milk, but is of great value in the treatment and cure of consumption. It costs less than cod-liver oil, and is quite as effective in the treatment of all forms of tuberculosis.

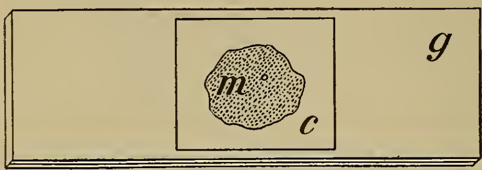


FIG. 37. — A tiny drop of milk prepared for examination with the microscope. *g*, glass slide; *m*, milk; *c*, thin piece of glass over the milk.

Condensed Milk. — This is cow's milk which has been heated to kill the germs and to evaporate about two thirds of the water. Sugar is often added to prevent the growth of any germs remaining. Some condensed milk is made from skim milk. Condensed milk should not be used regularly for feeding infants.

Souring of Milk. — The souring of milk is caused by bacteria. They are everywhere present in the air, on the cow, on the hands, and in the unclean milk pail. Most of them, when in milk not kept cold, grow very rapidly and change part of the milk sugar into an acid. Milk in a pail surrounded by ice may remain sweet a week, but if left in the warm living room will turn sour in a day. When milk becomes sour, there are usually about 250,000 bacteria in each drop.

Bacteria in Milk. — All milk sold contains bacteria. The number in each drop usually varies from 500 to 90,000. They are generally harmless to health. The milk while in the udder of healthy cows contains no bacteria, but thousands are present in the lower part of the canal of each teat. The first two or three squirts of milk, there-

fore, washes out hundreds of them. The milk pail is another source of bacteria. Wooden buckets cannot be kept clean and should never be used. A metal pail, rinsed with hot water and hung upside down, will in most cases after twelve hours contain more than a million bacteria. A single hair falling from the cow into the pail has been shown to have on it over 1000 bacteria, and every little particle of dirt brushed off from the udder adds from a hundred to several thousand germs to the milk. Others come from the unclean hands of the milker. The throwing down of hay or the kicking about of dry straw has been shown to fill the air with bacteria to such an extent that over 3000 per minute fell into the open milk pail.

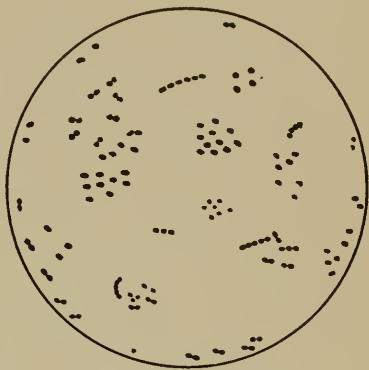


Fig. 38. — Drawing of the bacteria in the milk within the tiny circle shown in Figure 37, as seen through the microscope.

Milk immediately after being drawn from the cow usually contains from 200 to 2000 germs in every drop, depending upon the cleanliness of the milker, the cow, the pail, and the stable. Feeding the cows dry hay or cleaning the stables just before or during milking will quadruple the number of germs in the milk. Persons neglecting to wash the hands thoroughly before milking may infect the milk with the germs of scarlet fever, tonsilitis, diphtheria, or typhoid fever. The following table gives clear evidence that in warm milk the bacteria grow nearly a million times as fast as in milk kept in a cool cellar or in cold spring water.

Development of Bacteria in a Drop of Milk

Bacteria in Fresh Milk	After 9 Hr.	After 24 Hr.	After 48 Hr.	Temperature at which Milk was Kept
1500	250,000	1,000,000,000	unknown	summer heat, 94°
1500	30,000	200,000	1,000,000,000	living room, 68°
1500	3,000	10,000	2,000,000	cool cellar, 55°
1500	1,600	2,000	16,000	refrigerator, 45°
1500	1,550	1,600	2,500	packed in ice, 35°

How to produce the Best Milk. — The stable should be well lighted and have enough openings to admit plenty of fresh air. Except in very severe weather the cows ought not to remain in the stables between the milkings, because plenty of fresh air prevents tuberculosis. The floors should be cemented and kept clean, and the loose hair and dirt removed from the cows an hour before each milking. The udders can be cleaned with a damp cloth. Only tin or agate pails, washed with cold water and then with boiling water and soda, are to be used. *Neither a cloth nor the hands should touch the inside of a milk receptacle after it has been rinsed well with boiling water.* The milker should wash his hands thoroughly just before milking. Bacteria and dirt may be still further excluded by laying a piece of cheese cloth across the mouth of the pail and milking through it. Milk thus produced brings from ten to fifteen cents per quart in the market, and will make the highest quality of butter.

Care of Milk. — Although most of the market milk contains nearly 10,000 bacteria in each drop, milk produced in the way described above, and cared for properly,

contains only from 100 to 180 bacteria per drop. Such milk will remain sweet four days in an ordinary cellar during July. The *certified milk* which is approved by medical societies in cities usually contains less than 500 germs per drop and no bacteria which will produce disease.

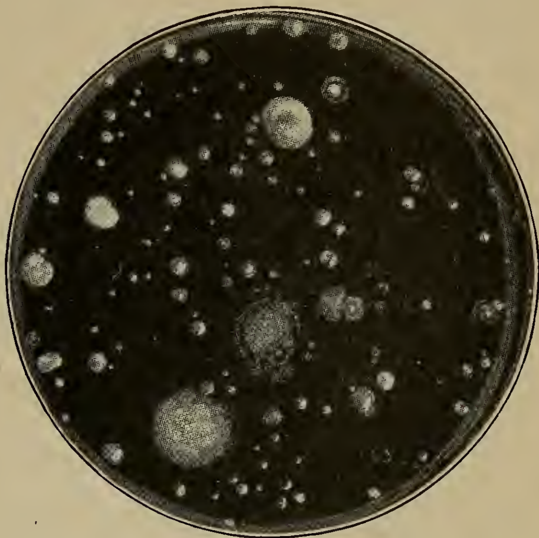


Fig. 39. — A dish with a thin layer of beef broth jelly, in which most bacteria will grow. A fly was allowed to walk around on the jelly a few minutes, and wherever it left a germ from its feet it grew to form a cluster or colony of germs within a day or two. Each white spot is a colony containing millions of bacteria which would have grown in much the same way if the fly had carried them into the milk.

Straining the milk immediately after milking, through one or two thicknesses of cheese cloth and a thin layer of absorbent cotton, will remove the finest particles of dirt and many bacteria. It is said that 300 pounds of dirt are consumed daily in the milk supplied to New York. As soon as strained, the milk should be cooled by means of a patent cooler or by placing the cans in cold water and stirring several times for a few minutes. It should then be kept in a clean cold room free from flies and all odors.

Milk ought to be sent to market in glass bottles sealed with paraffined pieces of pasteboard. The thousands of germs carried on the feet of flies and blown with the dust

into the milkman's measure are then avoided. Many of these germs come from spittoons and the filth in gutters. I have found as many as 800 bacteria per minute falling upon an area equal to the opening into an ordinary milk measure. Cream rises quickly on milk, and unless it is bottled as soon as milked, one customer will receive more and another less than the correct proportion of cream.

Adulteration. — Before the enactment of the pure food laws and the appointment of inspectors, a considerable amount of the milk in every town and city was adulterated with water, and had added to it chemicals to make it remain sweet. It is a crime to add anything whatever to milk. Every town should have an inspector to see that sickness and death do not occur on account of impure milk. It is responsible for much of the cholera infantum and other bowel troubles of children. In Rochester, from 1891 to 1896, when no special effort was made by the city to maintain a pure milk supply, 1000 more children died than during the years 1897 to 1902, when every effort was put forth to secure clean milk. Actual experience in the city of Leeds shows that among children using pure milk about one fourth less die than among those using the ordinary market milk.

Diseases conveyed by Milk. — Careful investigations by more than a hundred men prove clearly that sore throat, cholera infantum, typhoid fever, scarlet fever, diphtheria, and tuberculosis have been in many cases transmitted by means of milk. The germs of all of these diseases except tuberculosis and perhaps scarlet fever grow rapidly in milk not too cold. It has been shown that a single germ

of diphtheria dropped from the lips or hands into milk, can in twelve hours produce over 100,000 of its kind. The cow is not subject to any of these diseases except tuberculosis, and therefore the germs of the other diseases must find their way into the milk from the water, the hands, the clothing, the dust, or flies. Over 300 epidemics of infectious diseases, each affecting from 10 to 500 persons, have been caused by milk. Dirty cows, dirty stables, dirty hands, or dirty vessels used in the production of milk will sooner or later bring sickness and in some cases death to some of those using it.

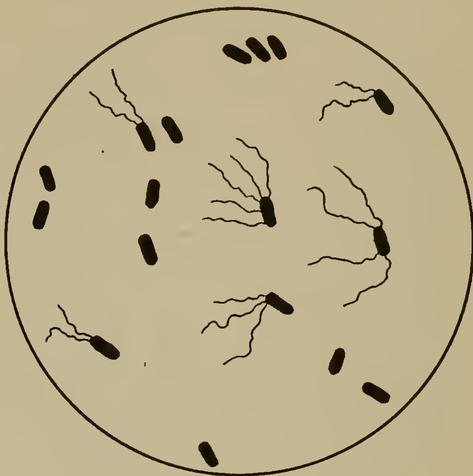


Fig. 40. — Drawing of typhoid germs as seen through the microscope.

Typhoid Fever and Milk. — At Cambridge, Massachusetts, there was a typhoid epidemic affecting 73 persons, all of whom had used milk from a farm where the father nursed his son sick with the fever and also did the milking. At Elkton, Maryland, in 1900, one milkman, whose wife assisted in caring for a typhoid patient and also did the dairy work, supplied 39 families with milk, and in every home from one to three members became ill with the fever. In 1903, in Palo Alto, California, 236 cases of fever resulted from the use of milk part of which came from a dairy along a stream known to contain typhoid germs. These reached the water from patients living on the bank

three miles above the dairy. The water from the stream was used to wash the milk cans. Over 200 epidemics of typhoid, each affecting from 10 to 500 persons, have been traced to milk as the source.

Diphtheria and Scarlet Fever in Relation to Milk. — Over 100 epidemics of these diseases are known to have had their source in the milk supply. At Ashtabula a hundred persons were infected with diphtheria, by germs from one dairy where a man with a light case of the disease helped care for the milk. In January and February of 1907 the milk of one company caused over 600 cases of scarlet fever in Boston and vicinity. No one who has suffered from any of these dangerous diseases should handle the milk until a month after recovery, because the germs sometimes remain several weeks in the system.

Fig. 41. — Intestine from child having tuberculosis. The half hundred little lumps are tubercles full of germs developed from a few which the child swallowed. Bureau of Animal Industry.

Tuberculosis and Milk. — Many cows have tuberculosis in a mild form. Very few herds kept most of the time in stables are free from this disease. The recent government reports indicate that over 1,000,000 cows in this country have tuberculosis, and some of them are shedding these germs into the milk, while nearly all tuberculous cattle give off the germs in their excretions.

There is no longer any doubt that children may acquire tuberculosis by using the milk of cows afflicted with this disease. Twelve girls, having healthy parents, contracted tuberculosis in a young ladies' boarding school in Paris. Five died, and an examination showed that the disease had begun in the intestines. The cow which had furnished the girls with milk was then suspected of being diseased and was killed. The milk ducts upon being opened were found to be badly affected with tuberculosis. Many similar cases are now on record. In some cities as many as 10 in every 100 samples of milk examined contained the germs of tuberculosis. It is a crime to sell the milk from cattle known to be diseased. The only way to determine whether a cow has tuberculosis is to have an expert use the tuberculin test.

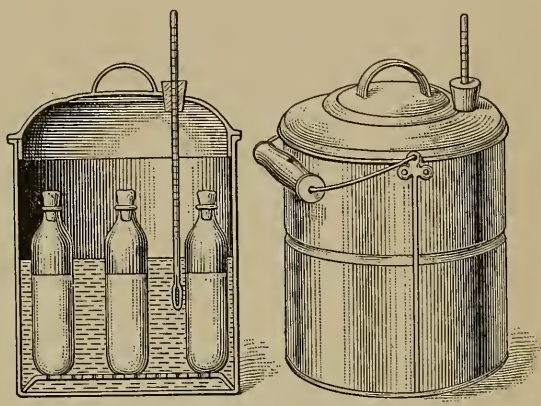


FIG. 42. — Pasteurizing apparatus.

Pasteurization. — When one is not sure that the milk to be given a child or invalid is perfectly fresh and clean, and from healthy cows, it is wise to pasteurize it. Pasteurization, so called from Pasteur the inventor, consists in heating the milk twenty minutes at about 160° Fahrenheit. This renders all disease germs harmless and kills most of the souring germs, but does not make the milk less easily digestible. Boiling renders the milk a little more difficult of digestion by a weak stomach, and

changes the taste. Pasteurized milk will remain sweet twice as long as raw milk.

The easiest way to pasteurize is to place the milk in a quart fruit jar or an agate vessel having the shape of a fruit jar. This is then to be set into a vessel of boiling water just removed from the stove, and the milk stirred with a clean spoon for ten minutes. It must then be covered and left fifteen minutes longer in the water, after which it should be cooled quickly by placing on ice or in cold water. It is necessary that the amount of boiling water in the teakettle or other vessel be four or five times as much as the milk, and deep enough so that its surface will be about on a level with the surface of the milk in the jar. If a glass jar is used, it must be placed on the back part of the stove a few minutes until it becomes about as warm as the hand to avoid being broken by the hot water. Pasteurized milk has saved the lives of many infants and invalids. A special pasteurizing apparatus, as shown in Figure 42, may be purchased for a small amount.

Questions

1. Of what importance is milk? 2. Give the composition of milk. 3. What can you say of the food value of milk? 4. By the table on page 41 compare the food value of milk and beef. 5. Show that milk at ten cents per quart is a cheaper food than eggs at twenty-four cents per dozen. 6. Explain the food value of skim milk. 7. What is buttermilk? 8. Of what value is cream? 9. How is condensed milk produced? 10. Why does milk become sour? 11. What are bacteria? 12. How do bacteria get into milk? 13. Explain the effect of temperatures on the bacteria in milk. 14. Give some directions to be observed in producing the best grade of milk. 15. What care should be given milk? 16. Why should milk be marketed in bottles? 17. State some facts about the adulteration of milk. 18. What disease germs grow after finding their way into milk? 19. How may the

germs of typhoid fever get into milk? 20. Give facts showing that no one caring for patients with diphtheria or scarlet fever should handle the market milk. 21. Give evidence showing that persons may acquire tuberculosis by drinking milk from tuberculous cows. 22. How may milk be pasteurized? 23. What is the benefit of pasteurization?

Suggestions for the Teacher

1. Ask the pupils to note whether the milk used at home leaves an unpleasant taste in the mouth. Pure milk gives no unpleasant afterflavor reminding one of the smell of a cow. Ask the pupils to observe whether there is any sediment in the milk pail or bottle after the milk has stood several hours and is then carefully poured off.

2. Ask some of the pupils to put the lid tightly on the milk can at night after washing it, and the following morning note the odor, due to the fact that the germs were not washed out clean. Babies fed milk from such vessels often get cholera infantum or other bowel trouble, which frequently results in death. Ask the same pupils to clean the milk can the next night by rinsing it well with cold water and then washing it out with boiling water and finally scalding it by placing it on the stove, with an inch or two of water in it, to boil five minutes with the lid on. Note the absence of odor the following morning.

3. If possible, have one of the pupils draw milk from the clean udder of a cow into a scalded glass jar, which should be immediately placed in a pan of cold water and stirred with a clean spoon ten minutes. Cover and keep cool, noting that it will remain sweet twice as long as milk cared for in the ordinary way.

VIII. NARCOTICS AND STIMULANTS

Characteristics. — *Narcotics* are substances which act on the system so as to relieve pain and tend to produce sleep. If taken in large doses, they cause a person to fall into a kind of a stupor or deep sleep. The commonest narcotics are tobacco, alcohol in large doses, opium, morphine, laudanum, paregoric, and many of the patent medicines.

Stimulants are substances which cause any organs of the body to act more vigorously than is their custom. Tea and coffee are stimulants frequently used. Neither narcotics or stimulants are necessary to enable an individual to make the greatest success in life. Moreover, it is well known that persons not accustomed to the excessive use of these drugs are much healthier and happier than those who are slaves to them.

Tobacco is a poison. Like other poisons, one may become so accustomed to its use by beginning with small doses and gradually increasing them, that large quantities smoked or chewed have but little apparent effect in older persons.

In certain parts of Italy some of the people have become so accustomed to the use of arsenic that they take ten times as much in a single dose as would be fatal to a person not in the habit of eating this poison.

The active principle in tobacco is *nicotine*. It is this which makes one so sick and sleepy when he for the first

time smokes even an inch of a cigar or takes one or two chews of tobacco. Tobacco consists of the dried leaves of the tobacco plant grown extensively in the valley of the Connecticut River and in Kentucky, West Virginia, and many other parts of the South, as well as in the West Indies. It cannot be considered a food, but it lessens the feeling of hunger by its sleep-producing effect.

How Tobacco Harms. — If there is an inherited tendency to cancer, the irritation of the membranes of the mouth by the constant presence of tobacco is likely to cause the disease to break out in that place. Catarrh, hoarseness, and throat trouble are common among those using tobacco to excess.

While a person is chewing tobacco, the salivary glands are kept in a continual state of activity, so that much saliva is lost in spitting. As a result the saliva that flows when food enters the mouth is of a poor quality, fails to act on the food properly, and then indigestion may be the consequence.

The nicotine absorbed by the vessels in the membrane of the mouth has, especially in the young, an injurious effect on the heart. About one fourth of all steady smokers show an irregular pulse beat. This condition has caused a large number of candidates for the United States Naval Academy to be rejected. Students in the Naval Academy are no longer permitted to use tobacco.

Alfred A. Woodhull, a surgeon in the United States Army, says: "Tobacco degrades the tissues generally, and it predisposes to neuralgia, vertigo, indigestion, and other disturbances of the nervous, circulatory, and digestive systems."

Cigarettes. — Cigarette smoking is the most harmful form in which tobacco is used. This is not due to the presence of more nicotine or other narcotic drugs. Cigarettes are especially damaging to health because it is the habit of those using them to inhale the smoke. This act carries the nicotine down into the air spaces in the lungs. Here it is much more readily absorbed than in the mouth. The user of cigarettes is also more likely to smoke to excess than one addicted to the cigar or the pipe. The use of the cigarette makes one more a slave to the drug, so that when he is deprived of it, a longing desire takes possession of him. He is unfitted for work or for enjoyment until another dose of the poison has been administered.

So pronounced is the opinion of the best people against the use of the cigarette that a number of states have passed laws prohibiting their sale. The supreme court of Tennessee made the following statement: "We think cigarettes are not legitimate articles of commerce, because they are wholly noxious and deleterious to health. Their use is always harmful, never beneficial. They possess no virtue, but are inherently bad, and bad only. They find no true commendation or merit or usefulness in any sphere. On the contrary, they are widely condemned as pernicious altogether. Beyond question their every tendency is toward the impairment of physical health and mental vigor."

Crime and Cigarettes. — Some railroad companies and numerous other business corporations demanding workers mentally, physically, and morally sound refuse to employ a person who is a cigarette smoker. The probation officer at Kansas City said that of 90 boys who had been

put in jail during six months of 1902 all but two were addicted to the use of cigarettes. A police magistrate in New York declares that 99 out of every 100 boys between the ages of ten and seventeen years who come before him charged with crime have their fingers stained with nicotine from cigarettes.

Opium and Morphine. — *Opium* is a sleep-producing drug made from the milky juice dripping out of the cut fruit capsules of the white poppy. The plant is grown in Asia Minor, Persia, and India. *Morphine* is a white powder separated from the opium by a chemical process. It is four times as strong as opium. Neither opium nor morphine should be taken except by the advice of a physician. Persons sometimes begin the use of these drugs to relieve them from pain or produce sleep, and after a few days' or weeks' use are unable to stop taking them. Like alcohol, they create an unnatural appetite which is only satisfied by constantly larger doses. Hundreds of persons are being treated yearly in sanitariums and otherwise to help them break loose from this terrible habit of using morphine and cocaine. *Cocaine* is made from the leaves of the coca plant. The numerous advertisements in the papers stating that medicines will be sent at slight cost to cure the morphine, cocaine, or alcohol habit are issued by fraudulent persons seeking to rob unfortunate people.

Laudanum is a mixture of opium, alcohol, and water, and is therefore a dangerous drug. *Paregoric* is a compound of opium, alcohol, camphor, and some other drugs.

Patent Medicines. — Most of the liquid patent medicines are stimulants or narcotics. Some have both properties. The narcotic contained in many of them is alcohol.

Nearly all contain more alcohol than beer, and many are richer in alcohol than the strong wines. A few have nearly as much alcohol as whisky has. It is just as dangerous and just as wrong to use these patent medicines as it is to use wine, whisky, or beer. The help which these nostrums seem to afford the sick is generally due to the alcohol which makes one feel good for a time. Late

FIG. 43. — Diagrams showing the amount of alcohol in alcoholic drinks and one of the most widely used patent medicines which has wrecked many lives.

investigations have shown that patent medicines have wrecked many lives and caused numerous untimely deaths.

Soothing sirups for children contain some kind of opiates which may ruin the constitution of a child. Most of the advertised *remedies for coughs* owe their soothing qualities to morphine or opium. Nearly all *catarrh powders* give temporary relief only because they contain opium or cocaine. Every one should remember that the constituents of the patent medicines claiming to cure all disease are known to our trustworthy physicians. If these reme-

dies helped the sick without injuring the health, they would of course be used by the reputable doctors. Some of our best newspapers and magazines, having lately learned of the worthlessness and evil effects of patent medicines, have refused to advertise them.

Tea. — Tea consists of the dried leaves of an evergreen plant grown in China. There are two general classes of teas, the one being black and the other green. *Black tea* is prepared by exposing the fresh leaves to the rays of the sun and later rolling and breaking them up. They are then allowed to ferment, after which they are again exposed to the sun and then dried in the oven.

In preparing *green teas*, the leaves are withered by heat or steamed, then broken up and sweated in bags, and finally roasted. For general use black tea is preferable to green tea because the tannic acid in it is less soluble. Tannic acid delays digestion, and on this account green tea used at mealtime may produce dyspepsia. In order to make any kind of tea so as to contain as little tannic acid as possible, the leaves should be placed in a jar and have boiling water poured on them. The jar must then be covered a few moments, after which the liquid tea is to be poured off into a clean vessel.

Tea contains practically no nourishment. The stimulating effect is due to *caffein*. The drinking of large quantities of tea may cause dyspepsia, heart trouble, sleeplessness, and other nervous disorders. Tea should not be used by children.

Coffee. — Coffee is prepared from the seeds of the coffee plant grown in Arabia, Java, Costa Rica, and Brazil. The seeds, often called beans, are made ready for use by

being dried in the oven, then roasted and ground. A cup of black coffee contains about as much tannic acid and caffein as a cup of strong tea.

It stimulates mildly the brain and heart and deepens the respirations. Coffee should not be taken by children or by those in ill health, as it tends to disturb digestion, and to produce nervousness and sleeplessness.

Chocolate. — Chocolate is made by grinding to fineness the kernels of the roasted seeds of the cacao tree. Chocolate contains a considerable amount of fat, starch, and proteids, and on this account it makes a nutritious drink. It also contains a small quantity of a mild stimulant which has little effect on the body. *Cocoa* differs from chocolate in that it has been deprived of a portion of its fat and has been more finely pulverized. It is an excellent drink for children and those recovering from illness.

Alcoholic Beverages. — Alcohol is such a health destroyer, has ruined so many homes, and resulted in so much crime and poverty, that an entire chapter is later devoted to the subject. While it is true that an adult can occasionally take a drink of wine, beer, or whisky without injury to health, yet there is always the probability that he may before he is aware of it develop the alcohol thirst now affecting over 1,000,000 people in this country. These drinks often wreck not only the body but also the character.

Questions

1. How does a narcotic differ from a stimulant? 2. Name some narcotics and stimulants. 3. From what is tobacco made? 4. How does tobacco injure the health? 5. Give evidence showing that tobacco is injurious to the young. 6. Why is the cigarette more harmful than the pipe or cigar? 7. Why have some states made laws preventing

the sale of cigarettes? 8. What evidence is there that cigarettes make criminals? 9. Why should one never use opium or morphine except on a physician's prescription? 10. State some facts about patent medicines. 11. Explain the danger in using soothing sirups and catarrh powders. 12. How is tea prepared for the market? 13. What is the proper method of making tea? 14. Of what use are tea and coffee? 15. In what way does cocoa differ from chocolate?

Suggestions to the Teacher

1. Boil for ten minutes an ounce of tobacco in a half pint of water. Place in the tobacco tea thus made an earthworm, a tadpole, or a snail, and note how soon it becomes unconscious from the narcotic effect of the tobacco.

2. Ask some of the children to make tea at home by boiling the leaves in water, and then make another cup of tea by merely pouring boiling water on the leaves. Note the difference in taste.

3. Assign to several members of the class the preparation of brief reports on the ingredients and use of certain harmful patent medicines. Information may be obtained from a booklet, The Great American Fraud, referred to on page 13.

IX. THE DIGESTIVE SYSTEM

THE ALIMENTARY CANAL

THE general cavity within the body is divided into two parts by the *diaphragm*, which is a dome-shaped sheet of muscle and tendon. Above the diaphragm is the *thoracic cavity*, surrounded by the ribs and other bones and also muscles forming the thorax. It contains the heart, lungs, esophagus, and large blood vessels. Below the diaphragm is the *abdominal cavity*, surrounded by structures constituting the *abdomen*. It holds the stomach, liver, spleen, pancreas, kidneys, bladder, intestines, and many large blood vessels. All the organs in the *body cavity* form the *viscera*. They are enveloped by a semitransparent, glistening membrane, named *serous membrane* because of the colorless fluid, the serum, which it extracts from the blood. It is this fluid which allows the organs to move freely against one another without friction. The serous membrane of the thoracic cavity is known as the *pleura*, while that in the abdominal cavity is called *peritoneum*.

Parts of the Digestive System. — The collection of organs used in grinding, mixing, dissolving, and otherwise changing the food so as to render it capable of being absorbed by the blood, together with the canal used in carrying the rejected remnants of the food out of the body, constitutes the digestive system. It consists of two chief parts, the *alimentary canal* and the assisting *glands* of digestion.

The divisions of the *alimentary canal* are the *mouth*, *pharynx*, *esophagus*, or *gullet*, *stomach*, and the coiled tube called the *intestines* filling up much of the abdominal cavity below the liver and stomach (Fig. 44). The *assisting glands* are for the purpose of secreting from the blood a liquid for softening and dissolving the food so that it may be taken into the tissue. They are the *salivary glands*, forming the saliva or spit, and the *liver* and *pancreas*, adjacent to the stomach.

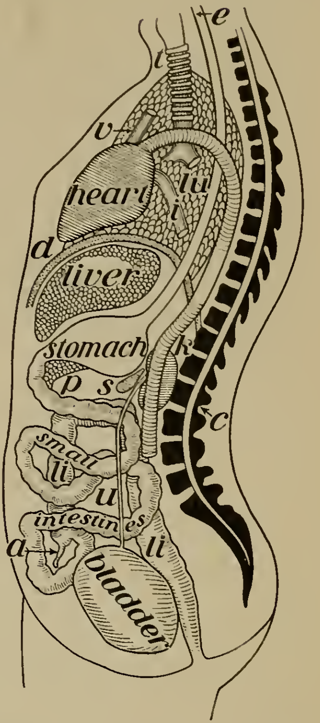


FIG. 44. — Diagram showing the relations of the organs of the body cavity, viewed from the side. *a*, vermiform appendix; *c*, spinal column inclosing the spinal cord; *d*, diaphragm; *e*, esophagus; *i*, the great vein, or vena cava; *k*, kidney; *lu*, lung; *li*, large intestine; *p*, pancreas; *s*, spleen; *t*, trachea; *u*, ureter; *v*, vena cava.

Mucous Membrane. — All surfaces exposed to the air are covered with one or more layers of epithelial cells. If the surface is not freely exposed, so that it may be cleansed by air, sunshine, and washing, the cells have the power to make from the blood a thin, slippery substance called *mucus* to serve as a cleanser. Such mucus-secreting cells, with the thin layer of underlying connective tissue, form *mucous membrane* (Fig. 45). It lines the entire alimentary canal and all other tubes of the body touched by air.

The Mouth. — The important organs in the mouth are the tongue and teeth. The *tongue* is composed of several muscles covered with mucous membrane, and is used in

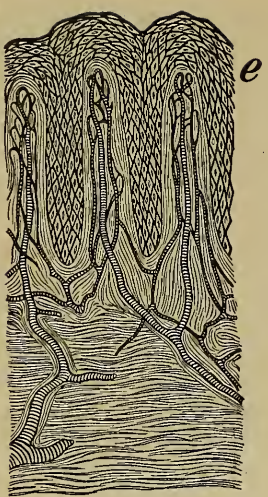


Fig. 45. — Section across a mucous membrane, showing blood vessels. Magnified. *e*, epithelial cells.

speaking and in moving the food about in masticating. In the adult there are 32 teeth, eight being in either half of each jaw. Because of their chisel shape, the two front ones in the half of each jaw are called *incisors*. The next one is the *canine*, the two following are the *premolars*, or *bicuspids*, and the three farthest back are the *molars*.

The incisors are for the purpose of cutting the food, while the molars, with their large, flat, grinding surfaces, serve to crush it. The teeth are set firmly in sockets about a half inch deep in the jaw bones. The thickened mucous membrane in the region of the teeth forms the *gums*.

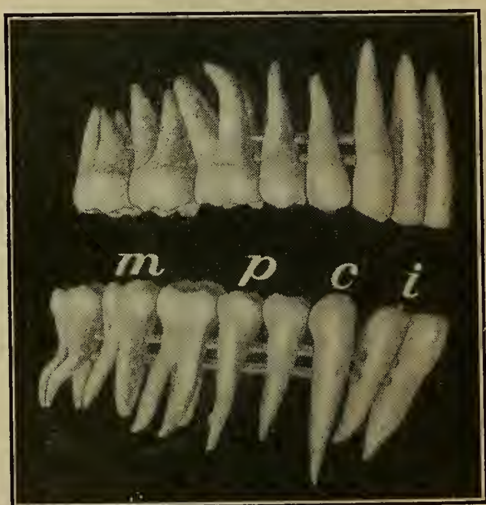


Fig. 46. — Mounted set of adult teeth. Photographed in the Wistar Institute of Anatomy. Viewed from the right side. *i*, incisors; *c*, canine; *p*, premolars; *m*, molars.

Milk Teeth. — An individual living to maturity has two sets of teeth. The first set, called *milk* or *temporary teeth*, are twenty in number. The two middle incisors of the lower jaw usually appear at the age of from four to eight months. A few weeks later the two

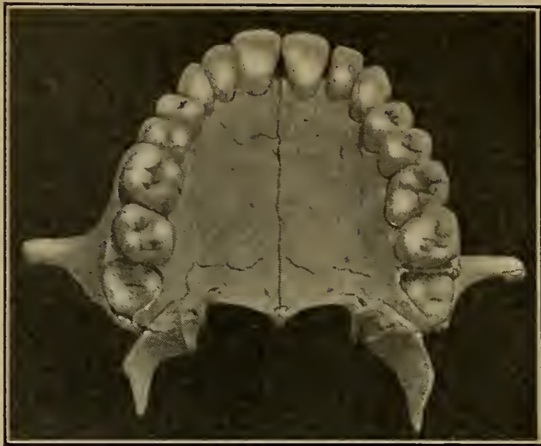


FIG. 47. — Roof of the mouth of a skull of a boy 18 years old. The last molars or wisdom teeth are breaking through. Photographed in the Wistar Institute of Anatomy.

middle incisors of the upper jaw break forth. At the end of the first year, the child should have all the eight incisors. The four canines or eye teeth appear during the second year, the first premolars in the third year, and the second premolars between the fourth and sixth years. At this time the permanent teeth begin to grow beneath the milk teeth, and by pressure against the blood vessels cut off their nourishment, causing the roots to be absorbed, so that the milk teeth drop out between the seventh and twelfth year, or may be easily pulled, as they are held fast only by mucous membrane.

FIG. 48. — Milk teeth of a child from the left side. *c*, incisors; *i*, canines; *m*, premolars. Photographed in the Wistar Institute of Anatomy.

Sometimes the second set of teeth do not press in such a way as to cut off the nourishment of the first set, but appear at the inner or outer side of them. Unless the milk teeth are then ex-

tracted, the permanent ones will project and disfigure the countenance and also be in the wrong position for chewing. The twelve permanent molar teeth are not preceded by any temporary teeth. The first pair of these in each jaw appear at the age of six years; the second pair during the twelfth or thirteenth year; and the last pair, called the *wisdom teeth*, break through between the seventeenth and twenty-fifth year of life.

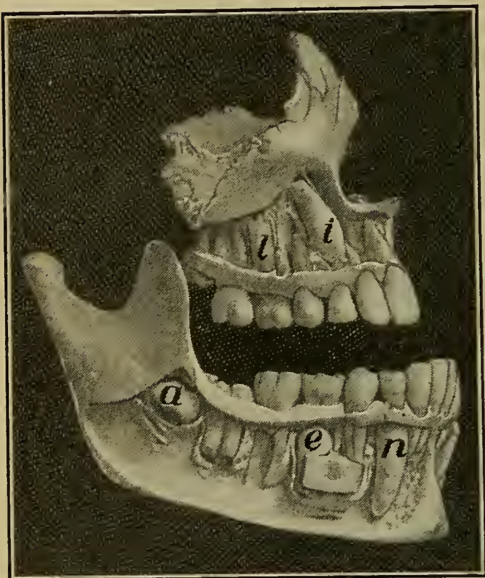


Fig. 49.—Part of a skull, with the side of the jaw bone cut away to show the teeth. *a*, *e*, *n*, *l*, and *i* ready to break through the gum. Photographed in the Wistar Institute of Anatomy.

Structure of a Tooth.—The part of a tooth above the gum is the *crown*, the part below the gum is the *root*, or *fang*, and the constricted region between these two parts is the *neck*. The hard interior part of a tooth is the *dentine*, which is a bonelike substance. The *crown* is covered with a very hard, glistening substance known as *enamel*, while the surface layer of the fang is *cement*. The small cavity within the tooth is filled with *pulp*, which is a soft mass of fatty material, together with blood vessels and nerves entering at the tip of the root. The two large tusks of the elephant used for ivory are the overgrown incisor teeth made of very compact dentine.

Care of the Teeth. — There are always living in the mouth several kinds of bacteria, some of which, when present in large numbers, cause the teeth to decay. Therefore the teeth should be brushed twice daily with a brush dipped in warm water.

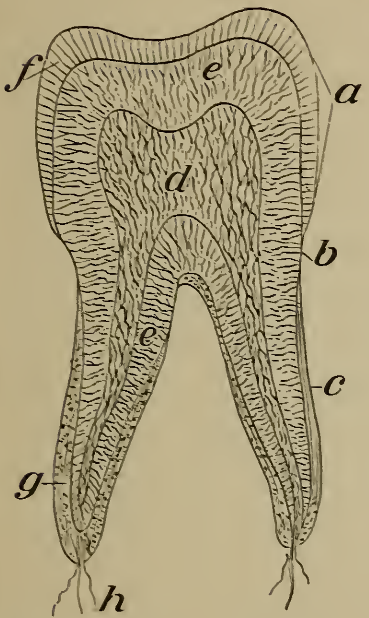


Fig. 50. — Section through a tooth. *a*, crown; *b*, neck; *c*, fang; *d*, pulp of blood vessels and nerves; *e*, dentine; *f*, enamel; *g*, cement; *h*, nerve.

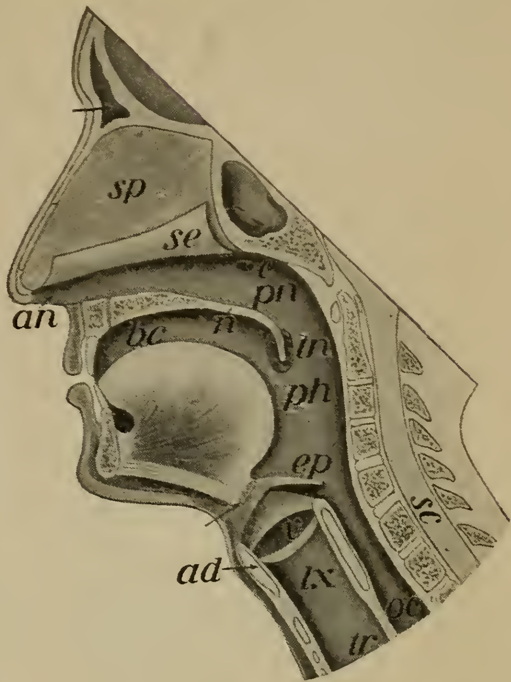


Fig. 51. — Section from before backward through the front part of the head. *ad*, Adam's apple, or cartilage of the larynx; *an*, nostrils, or anterior nares; *bc*, mouth; *ep*, epiglottis; *e*, Eustachian tube; *n*, soft palate; *pn*, posterior nares; *ph*, pharynx; *lx*, larynx; *oe*, esophagus; *sc*, spinal cord; *se*, part of the septum turned up; *sp*, dividing the nostrils; *tr*, trachea; *tn*, tonsil partly hid by the uvula; *v*, is just above the vocal cord.

The removal, after eating, of the particles of food clinging to the teeth, by means of a strong thread or wooden toothpick, will help much in preventing decay. A metal pick should never be used, as it is likely to break or

scratch the enamel, and it is this hard covering which prevents the bacteria from entering the dentine to cause decay. The enamel is often broken by cracking nuts or biting other hard substances.

The whitish material called *tartar* is a limy deposit from the saliva. It should be removed once or twice a year by a dentist, who can then discover any cavities present and at once fill them, thus stopping further decay. The milk teeth as well as the permanent set frequently decay and need to be filled. Poor teeth lead to ill health in many persons and are responsible for much neuralgia and indigestion.

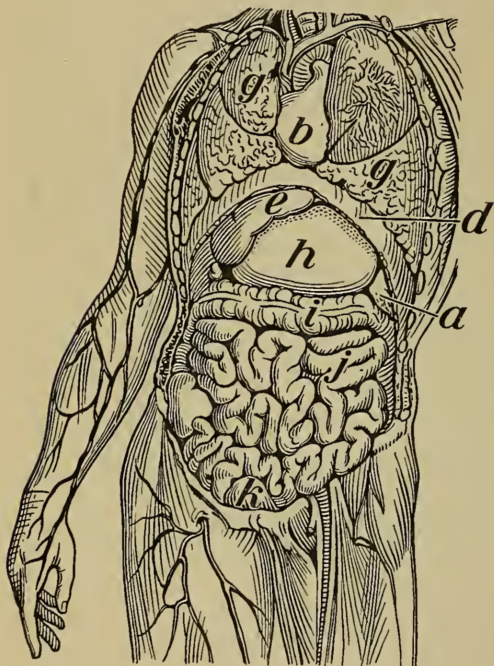


FIG. 52. — Front view of the viscera. *a*, spleen; *b*, heart; *d*, diaphragm; *e*, liver; *g*, lung; *h*, stomach; *i*, large intestine; *j*, small intestine; *k*, bladder.

Pharynx and Esophagus. — The irregular cavity back of the mouth and in the throat region is the *pharynx*. The passages conducting air through the nose open into its top part, and from either side a small canal called the *Eustachian tube* leads up to the middle ear, while from the back part extend the esophagus and larynx. The conical body hanging from the soft palate forming the roof of the posterior portion of the mouth is the *uvula*.

An oval body a half inch long and buried in the mucous membrane on either side of the root of the tongue is the *tonsil.* Its use is unknown. A growth of certain bacteria on it and other parts of the throat causes *tonsilitis*, which may be conveyed from one member of a school to another by the use of a common drinking cup.

The pharynx narrows into the *esophagus* just back of the larynx, whose large part forms beneath the chin a projection known as Adam's apple. The esophagus is a half inch in diameter and nine inches long. Its muscular coat aids in propelling food from the mouth to the stomach, and the mucous lining secretes enough fluid to keep the interior well moistened.

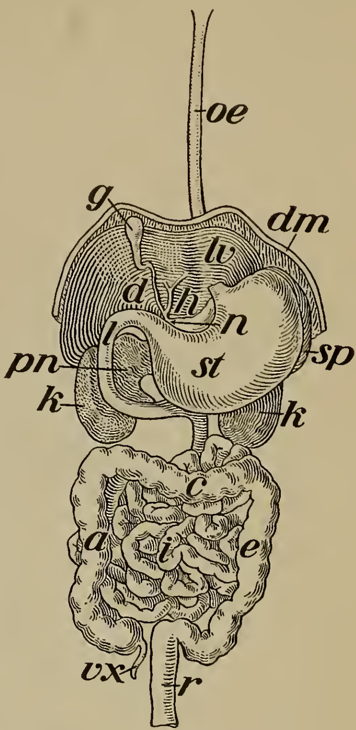


Fig. 53. — Front view of the organs of digestion removed from the body. *a*, *c*, and *e*, colon; *d*, duct of the gall bladder; *dm*, diaphragm; *g*, gall bladder; *h*, hepatic duct from the liver; *k*, kidney; *l*,*i*, small intestine; *lv*, liver; *n*, opening of the bile duct into the small intestine; *oe*, esophagus; *pn*, pancreas; *r*, rectum; *st*, stomach; *sp*, spleen; *vx*, vermiform appendix.

The Stomach. — The esophagus opens below the diaphragm into the stomach. This is an enlargement of the alimentary canal for the purpose of holding the foods from one to five hours while the juices it secretes act on them. It has the form of a long hen's egg, and is capable of holding over two quarts. Its muscular coat, made of involuntary muscle arranged in

three layers, keeps the food in motion while the glands of the mucous membrane force out the gastric juice. This softens and more or less dissolves the food, which is retained the proper time by a circular muscle forming the *pylorus*, the opening of the stomach into the intestine.

The Intestines. — The small intestine is a very much coiled tube about 25 feet in length, and is over an inch in diameter. The two layers of involuntary muscle forming the muscular coat serve to move the food along and mix it with the secretion from the thousands of little glands forming much of the inner or *mucous coat.* From this coat millions of minute, fingerlike processes, the *villi* (Fig. 61), no thicker than a hair and one sixteenth of an inch long, project and take up the nourishing portions of the food.

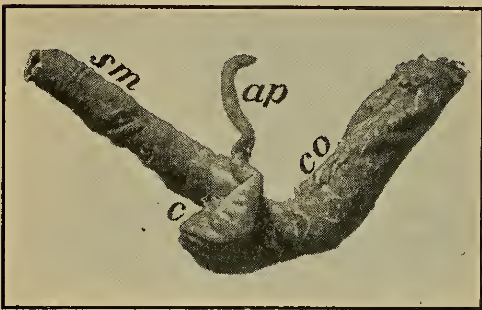


Fig. 54. — The small intestine joining the large one. *ap*, vermiform appendix; *c*, beginning of the large intestine; *co*, colon; *sm*, small intestine.

The small intestine leads by a valve into the large intestine at the lower right side of the abdominal cavity. The colon and rectum are the main parts of the large intestine.

Vermiform Appendix. — The vermiform appendix is a blind tube projecting from the large intestine. It is as large around as a lead pencil and from one to six inches in length. Its cavity is scarcely larger in diameter than the head of a pin, so that it sometimes becomes clogged up

with material from the intestine. This may cause a very rapid growth of the bacteria present, and as a result the organ becomes inflamed and often must be removed to prevent the bacteria from eating through into the abdominal cavity. This inflammation of the appendix is called *appendicitis*.

The appendix has no function in man at present, but millions of years ago it was wider and longer, and then was of service in digestion, as is the case now in the rabbit, groundhog, and cow.

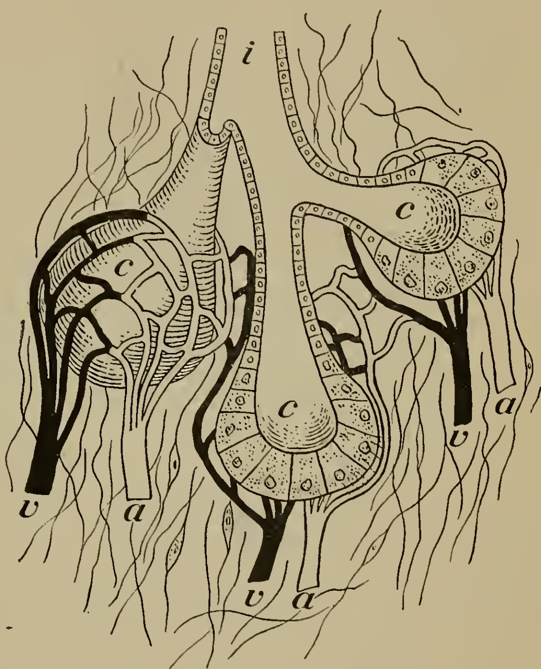


FIG. 55. — Diagram of a gland. *c*, alveolus, or enlarged end of tube; *i*, common duct to carry off the secretion made by the cells from that part of the blood passing through the walls of the capillaries; *a*, arteries; *v*, veins.

GLANDS OF DIGESTION

The Nature of a Gland. — A gland is a simple tube lined with cylindrical cells, or a collection of such tubes, all of which may be branches of the one main tube called a *duct*. The purpose of a gland is to manufacture some special material from the blood. The thousands of gastric glands in the walls of the stomach and the intestinal glands of the intestines are simple or slightly branched tubes too small to admit

a hair. Nearly all mucous membrane contains in it glands for secreting mucus with which to moisten the surface and prevent the entrance of germs.

Salivary Glands. — Three pairs of very richly branched salivary glands pour their secretions into the mouth. The *parotid gland* lying just beneath the skin and below the ear forms an irregular, flat mass about as large as the ear. Its duct opens on the inner side of the cheek. The *submaxillary gland* is somewhat the size and shape of an almond, and lies between the lower jaw and base of the tongue. Its duct opens beneath the tongue on a papilla visible to the naked eye. The *sublingual gland* is the smallest, and lies under the tongue in front of the submaxillary. Its several ducts open beneath the tongue. The secretions of these three pairs of glands, together with the glands of the mucous membrane of the mouth, form the saliva, which acts on the starch of food.

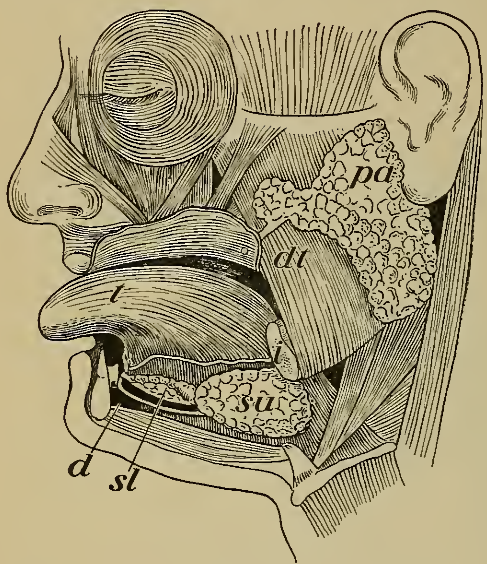


FIG. 56. — Skin removed and front part of the lower jaw cut away to show the salivary glands. *pa*, parotid gland; *su*, submaxillary gland; *sl*, sublingual gland; *dt*, duct of parotid gland; *d*, duct of submaxillary gland; *t*, tongue.

Gastric Glands. — The mucous membrane lining the stomach is composed almost entirely of tubelike gastric glands arranged side by side and held in place by a little

connective tissue between them. They yield *pepsin*, *rennin*, and *hydrochloric acid*. These substances, dissolved in a watery liquid issuing also from the glands, form the gastric juice which acts on the proteids of the food.

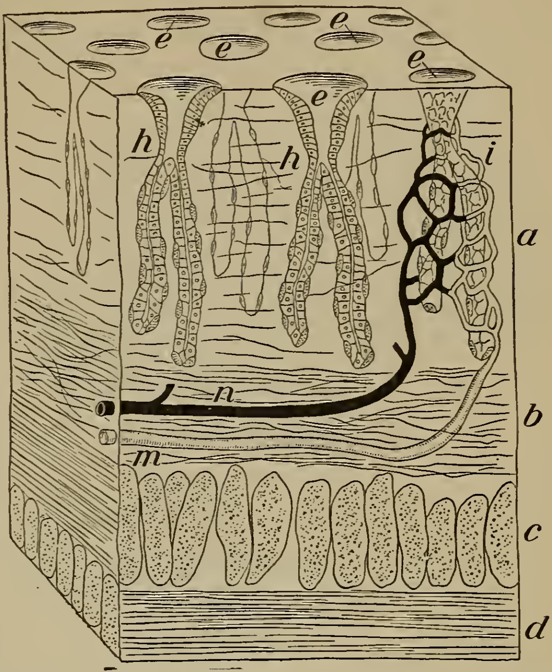


FIG. 57. — Diagram of a tiny block of tissue smaller than a pin's head, cut from the wall of the stomach. *a*, mucous membrane; *c* and *d*, muscular coats; *e*, mouths of gastric glands; *h*, gastric glands; *i*, capillaries supplying the gastric glands with blood; *m*, artery; *n*, vein.

Intestinal Glands. — The mucous membrane of the intestine is composed largely of simple, tubelike glands standing side by side, with their mouths opening at the bases of the villi which stick out into the cavity of the intestine. These glands secrete about three quarts daily of a watery fluid containing several products of great importance in digestion.

The Liver. — The liver is of a brownish red color, and is the largest gland in the body, being about equal in size to the upper half of the head. It lies immediately under the diaphragm. A number of deep incisions separate it into five *lobes*, each of which is made of thousands of *lobules* about the size of a pin's head. A lobule consists of several

hundred cells having the power of separating certain substances from the blood and manufacturing them into a dark green liquid called *bile*. This escapes from the liver through the *hepatic duct* leading to the small intestine near its junction with the stomach. A branch from the hepatic duct carries the excess of bile to the *gall cyst*, or *gall bladder*, where it is stored until needed for digestion. A most important use of the liver cells is to act on certain parts of the food brought by the blood vessels from the intestine and hold some of it in storage for a time.

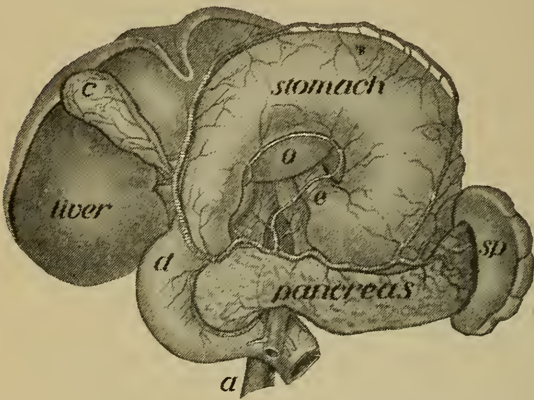


FIG. 58. — Front view representing the stomach pulled up to show the pancreas. *a*, aorta; *c*, gall bladder; *d*, stomach end of the small intestine; *e*, esophagus; *o*, liver; *sp*, spleen.

The Pancreas. — The pancreas is a pinkish white gland having somewhat the shape and size of the little-finger half of the hand. In butchered animals it is known as one of the *sweetbreads*. It extends from the curve of the stomach end of the small intestine across the body back of the stomach. Its cells form nearly a quart of juice daily, which is carried by numerous small ducts into a larger tube, the *pancreatic duct*. This enters the small intestine with the bile duct. Sickness of certain kinds of cells scattered in bunches throughout the pancreas causes *diabetes*, an incurable disease characterized by sugar in the blood.

Questions

1. Name the contents of the thoracic cavity. 2. What organs are located in the abdominal cavity? 3. What is the peritoneum? 4. Name the assisting glands of digestion. 5. Describe a mucous membrane. 6. Give eight facts concerning an adult's teeth. 7. At what age do the milk teeth appear? 8. When do the milk teeth give place to the permanent teeth? 9. Name the parts of a tooth. 10. Give some points concerning the care of the teeth. 11. Name the parts seen in your mouth wide open when you are standing before a mirror. 12. What is a tonsil? 13. Locate the stomach. 14. Write five important facts about the intestines. 15. What is a gland? 16. Locate the salivary glands. 17. Give three facts about the gastric glands. 18. Describe the liver. 19. Point out the location of the liver on your own body. 20. State five facts concerning the pancreas.

Suggestions for the Teacher

1. Exhibit a full set of teeth, which may usually be had for the asking from a dentist. Crack a tooth open and note the structure.

2. Ask the children to examine the mouths of the younger ones at home and report what teeth are present and whether any are coming in out of place.

3. The entire alimentary canal of a cat, squirrel, or rabbit may be removed from a freshly killed animal and kept for demonstration for many years, if placed in a jar of formaldehyde solution (formaldehyde, three tablespoonfuls, and water, one quart).

X. HOW FOOD IS DIGESTED

The Meaning of Digestion. — When food is taken into the mouth, it is not in such a state that the blood vessels are able to absorb it and carry it to the cells in all parts of the body. Dry food to be readily swallowed must be broken up and well moistened. The stomach is of such a nature that it will usually not allow any substance to pass out of it before the substance has been softened and made into a liquid state. The food on reaching the intestine is changed into a more perfect solution.

The operations of chewing, softening, dissolving, and otherwise changing the food so as to fit it to pass through the cell walls into the vessels for transportation, constitute the process called *digestion.* The changes produced in the food digested are due largely to the ferments made by the glands in the walls of the alimentary canal and by the salivary glands and pancreas. *Ferments* are substances formed by living cells and are capable of acting on food without any change taking place in themselves. About a dozen kinds of ferments are generated in the body.

Mouth Digestion. — The touch, taste, and odor of food cause the salivary glands to send forth an abundance of *saliva.* About one pint is secreted daily. It contains the important ferment which acts on the starch of foods so as to change it to sugar. The time required for this transformation is from ten minutes to twenty minutes for

cooked foods, and from one hour to two hours for those uncooked.

The saliva does not continue to act on the food more than an hour after it enters the stomach, because the food has then become mixed with the acid gastric juice, which stops the action of the ferment.

Importance of Thorough Mastication. — Mastication means chewing the food. It has been well and truthfully said that if every mouthful of food were chewed for one minute, the common complaint about indigestion would seldom be heard. Much chewing of food produces much saliva and a complete mixture of the two, so that the ferment may reach every particle of the starch. Moreover, the pleasant taste and odor of food, prolonged by mastication, excite the flow of the digestive juices in the stomach. Gladstone is said to have accounted for his long life and excellent health by the fact that he chewed each mouthful of food at least thirty times.

FIG. 59. — Top view of the tongue. *l*, circumvallate papillæ; *e*, epiglottis.

Taste and Odor of Food. — In the dozen or more large circumvallate papillæ on the back part of the tongue and in other portions of the tongue and mouth cavity are minute oval bodies called *taste buds* or *organs of taste*. From each a nerve fiber leads to the brain. The food which excites these end organs must be in solution, and for this

the watery saliva is well adapted. A minute or two is often required to effect this solution, and because of this, food swallowed hastily has but little taste. Since anything pleasant to the taste stimulates greatly the flow of the digestive juices, it is wise for one to select delicious eatables. Much of the pleasing effect of taking food is due to the odor. Such articles as coffee, tea, grapes, horse radish, and onions affect the sense of smell much more than that of taste. This may be readily determined by holding shut the nostrils while chewing and swallowing.

The Chewing of Gum and Tobacco. — Pepsin chewing-gum, which is widely advertised as a remedy for indigestion, owes its usefulness not to the pepsin it contains but to the pepsin which it causes the stomach to produce. The sweet taste and the chewing act on the nerves controlling the flow of the saliva and the gastric juice. The chewing of dry bread or crackers aids digestion quite as much as the use of gum.

The chewing or smoking of tobacco causes a great waste of valuable saliva, as it is spit out of the mouth. On this account the use of tobacco is an uncleanly habit as well as an unhealthy one, especially for the young. The stale odor always clinging to the person and clothing of the constant user of this weed is very unpleasant to most women and many men. Tobacco not only lessens the natural appetite for food and the power of digestion, but has such a pernicious effect on the health of youth that the Minister of Public Instruction in France issued a circular forbidding the use of tobacco in the public schools.

Stomach Digestion. — The food at the first part of a meal is, in a few minutes after entering the stomach, mingled

with the acid gastric juice, but that entering later is not affected by the stomach secretions for a half hour or more. It remains near the entrance, and the saliva from the mouth continues its action. The *gastric juice* is composed of a watery liquid containing a small amount of *hydrochloric acid*, *pepsin*, and *rennin*. The last two are ferments. Pepsin changes the proteids to *peptones* so that they can be taken up by the blood vessels of the intestines. Rennin curdles milk. The food, when ready to pass from the stomach through the pylorus, is similar to thick gravy and is called *chyme*.

How the Gastric Juice is Formed. — The 5,000,000 microscopic tubelike glands completely lining the interior of the stomach manufacture from the blood the gastric juice. The glands are made to act either by the taste and odor of food or by the presence of food in the stomach. At the beginning of the meal certain foods, such as cake, bread, and potatoes, cause a much less flow of juice than soups and meat. On this account a small amount of soup at the beginning of the meal is helpful to digestion. As a pleasing odor and taste tend to increase the amount of stomach secretion, the kind of food easily digested by one person may cause dyspepsia in another. Grief or mental excitement tend to decrease the action of the gastric glands.

Movements of the Stomach. — In order that the food may be moved forward and mixed with the gastric juice, the stomach must perform certain movements. It was once thought that these movements were of such a nature as to cause the contents of the organ to pass round and round from one end to the other. Lately it has been

shown by the use of the X rays on man and by experiments on rats that no such rotary motion of the food occurs. The large end of the stomach has little or no motion, while contraction of the circular fibers begins about the middle and extends toward the pylorus, squeezing and mixing the food with the juices. One wave of contraction after another begins at the middle and progresses toward the small intestine, tending to press the contents of the stomach into the intestine. The material is prevented from leaving the stomach by the contraction of a ring of muscle, the pyloric valve, which relaxes only when pushed against by a liquid.

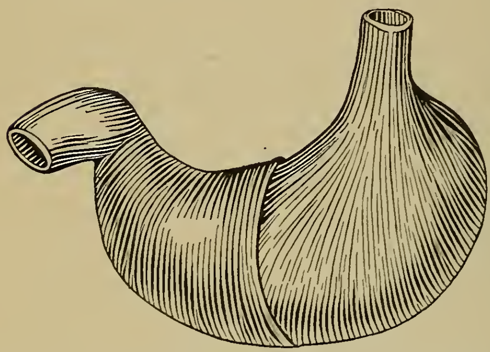


FIG. 60. — The stomach, with the circular muscle fibers removed from the right half to show the other muscular fibers.

Time Required for Digestion. — The length of time required for gastric digestion depends upon how well the food is masticated, how it is cooked, the kind of food, and the character of the gastric juice. The strength of the gastric juice is much greater in healthy adults than in infants and invalids. Observations on the food in the stomach have been made through a hole formed by a gunshot wound, and further information as to digestion has been gained by pumping out the contents through a rubber tube at various intervals after certain kinds of products have been eaten. The following tables show the time required for the digestion of some of the common foods: —

	Hours		Hours
Rice, boiled	1	Beef, boiled	$2\frac{3}{4}$
Eggs, raw and whipped	$1\frac{1}{2}$	Beef, roasted	3
Eggs, raw	2	Beef, fried	4
Eggs, soft boiled	3	Oysters, raw	$2\frac{3}{4}$
Eggs, hard boiled	$3\frac{1}{2}$	Oysters, stewed	$3\frac{1}{2}$
Milk, boiled	2	Bread, white	$3\frac{1}{2}$
Milk, raw	$2\frac{1}{4}$	Bread, corn	$3\frac{1}{4}$
Brains, boiled	$1\frac{3}{4}$	Mutton, roasted	$3\frac{1}{4}$
Potatoes, roasted	$2\frac{1}{2}$	Pork, roasted	$3\frac{1}{4}$
Beans, in pod, boiled	$2\frac{1}{2}$	Cabbage, boiled	$4\frac{1}{2}$

Results of Overeating. — When the stomach is too full, its natural movement cannot take place. As a result, the gastric juice is small in quantity and changed in quality and is not properly mixed with the food. These conditions cause an irritation of the nerve endings in the lining of the stomach, producing a feeling of sickness. If then the pylorus does not allow the undigested food to pass, vomiting occurs. Many headaches are due to an overloading of the stomach. Eating more than three times a day is likewise unhealthy for any one except invalids and children whose diet consists largely of milk. The digestive glands are prevented from resting, and therefore give out a weak juice of poor quality. Candies and other sweets often cause digestive disorders if taken at any other time than at the close of the meal.

Use of Fluids with Meals. — Very hot or very cold fluids hinder digestion, because they decrease the flow of the gastric juice. The use of more than one glass of water at a meal is usually not desirable, as the stomach secretion is liable to be too much diluted. It is especially harmful to wash the food down the throat by taking a swallow of coffee or tea after every two or three bites of food.

A vast amount of experience shows it is unwise to use habitually beer, wine, ale, or any other form of alcoholic drink. The large amounts of these narcotics so often taken hinder digestion. The Committee of Fifty, who recently studied this question, state that chronic inflammation and catarrh of the stomach are common among those using alcohol to excess. Dr. Woodhull, of the United States Army, says: "Its use in health only disturbs health, leading to numerous diseases. So much ill health ultimately depends upon alcoholic indulgence that the habitual drinker both lays the foundation for serious disturbances and steadily builds upon it." The government reports of Switzerland, where alcohol is moderately used, state that one in every ten deaths of men over twenty years of age results from alcohol. Wine may in rare cases be of some benefit to digestion, but the late work of Horsley and Sturge shows that alcohol enfeebles the churning action of the stomach and thus delays digestion.

Intestinal Digestion.— The most important part of the digestive process is carried on in the small intestine. In order that the liquid chyme may be thoroughly acted on by the juices in the intestine, it is forced out by the stomach in small amounts at intervals of one or two minutes. Two or three quarts of *intestinal juice* are secreted daily by the microscopic tubular glands forming much of the lining of the intestine. This juice contains four ferments, one of which splits up the proteids, another changes the common sugar to grape sugar, and a third stimulates the flow of the pancreatic secretion.

Pancreatic Juice. — The pancreas secretes nearly a quart of fluid daily, which contains the most important of all

the ferments for digestion. One changes starch to sugar, a second transforms the proteids into peptones, and a third splits the fats into glycerin and fatty acids. The acids unite with some of the alkali present in the bile and other juices, and thus form soap. In this way the starch which escapes the action of the saliva, and also the proteids unchanged by the gastric juice, are perfectly digested in the intestine. The dark liquid mass of food material, composed largely of peptones, soap, and sugar, is now ready for absorption, and is called *chyle*.

FIG. 61. — Slice of the wall of the cat's small intestine. *i*, villi; *n*, intestinal glands; *m*, muscular coat. Magnified.

The Bile. — The bile is a greenish yellow liquid which is secreted by the liver at the rate of more than a pint daily. When there is no food in the intestine, it is stored in the gall bladder, capable of holding a third of a teacupful. The bile has in itself no digestive power, but hastens the action of some of the other juices. It also contains some waste matter from the body. When the bile duct becomes clogged, much of the fats escapes digestion, and the bile then gets into the blood and produces a disease called *jaundice*.

Movements of the Intestines. — The longitudinal and circular muscular coats serve to give two movements to the intestines. *Peristalsis* or the *peristaltic movement*

consists of a wave of contraction of the circular muscle, which passes along from the stomach end onward, and thus presses the food down the canal. Another movement is the swinging to and fro of several folds of the intestine by a kind of rhythmical contraction of the circular and longitudinal muscles. These motions not only propel the food toward the large intestine, but also mix it thoroughly with the digestive juices.

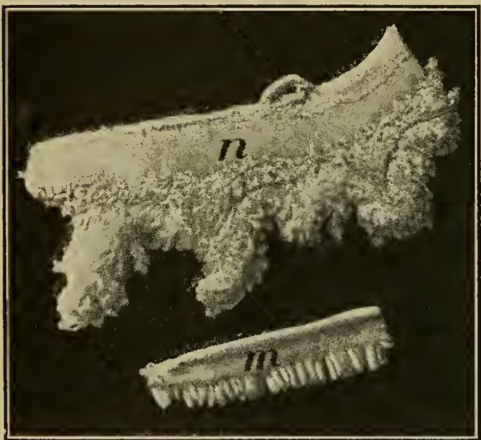


FIG. 62. — Slices of the small intestine. *m*, cat; *n*, human. A score of villi are seen on the intestine of the cat. The four folds of the mucous coat seen in the human intestine bear dozens of villi appearing as tiny shaggy projections scarcely separated from one another. Magnified.

The food remains in the small intestine from five hours to fifteen hours, during which time most of the nourishing part is absorbed into the blood. The refuse passes into the large intestine, from which it should be ejected daily at about the same hour. Failure in performing this important act regularly causes constipation, which results in much ill health.

Absorption from the Intestine. — More than nine tenths of all the food reaching the blood has been absorbed by the villi of the small intestine. There are more than 20,000 of them to every square inch. Each *villus* is composed chiefly of a layer of cylindrical cells covering a core made of a network of *blood capillaries* surrounding a sin-

gle vessel leading into the *lacteal system* (Fig. 63). The food passes through the epithelial cells, and then the fats are taken up by the lacteal vessels, while the other part of the food is absorbed by the blood capillaries uniting to form the *portal system* leading to the liver (Fig. 64).

The Lacteals. — These vessels form a part of the lymph system, which serves to return to the veins in the neck that portion of the blood constantly oozing out of the capillaries in all regions of the body. The lacteals consist of millions of minute vessels beginning blindly in the villi and other parts of the intestine and uniting into a score or more of threadlike tubes which converge in their course to enter the lower part of the left *thoracic duct* (Fig. 64). This duct is a tube about as large as a lead pencil, lying in front and to one side of the backbone. It leads into a large vein in the neck. The fats, upon entering the lacteals, are forced along by the pressure of

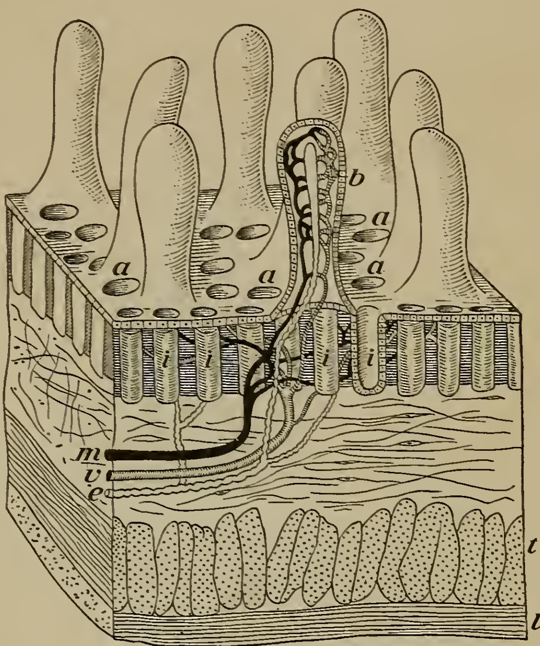


Fig. 63. — Diagram of the structure of a block of tissue smaller than a pin's head, cut from the wall of the small intestine. *a*, mouths of the intestinal glands; *b*, villus cut lengthwise to show the blood capillaries and white lacteal within; *e*, lacteal vessel sending branches to many villi; *i*, intestinal glands; *m*, artery; *v*, vein; *l* and *t*, muscular coats.

the moving intestines, by breathing, and also by the suction in the thoracic duct caused by the rushing along of the blood past its mouth. If a cat or dog be given a meal of rich milk and killed about three hours later, the numerous small lacteal vessels will appear white, because of the fat in them.

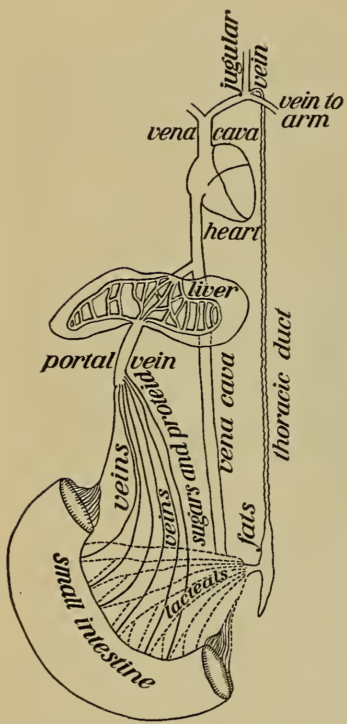


FIG. 64. — Diagram showing how the food reaches the heart to be sent with the blood to all parts of the body.

The Portal System. — The portal system consists of a large *portal vein*, with its tributaries beginning in the capillaries of the intestine, stomach, and other abdominal organs, and its branches ending in the capillaries of the liver. The capillaries do not actually terminate in the liver, but are continuous with the capillaries forming the *hepatic vein* carrying blood away from the liver. Through this portal system all the food except the fats are transported from the villi to the liver.

How Food passes through the Intestinal Wall. — Since the alimentary canal is merely a tube through the body, food while in it is not within the body where it can be used by the tissues. The final product of digestion in the small intestine is the chyle, which passes into the villi by three processes: 1. *osmosis*, which is the tendency of two liquids of different density separated by a membrane to mix; 2. *filtration*, which is the

forcing of a liquid through a membrane by pressure such as would occur when the muscular walls of the intestine contract; 3. *imbibition*, which is the property possessed by a cell of drinking in a liquid in contact with it, somewhat as a sponge absorbs water.

Osmosis may be shown with the egg experiment (Fig. 66). By cracking the shell on the large end of an egg it may be removed without breaking the thin skin beneath. Through a hole made in the small end of the egg a knife blade may be thrust down to pierce the membrane around the yolk. A glass tube is then to be pushed through the small end into the yolk, and the tube firmly cemented to the shell with paraffin or sealing wax melted in place with a hot nail. The egg is then placed tube up in a glass of water, and propped up with a stick so as to be only half immersed. In less than an hour enough water will have passed through into the egg to force the yolk far up in the glass tube, but none of the proteid of the egg will have been pushed through the membrane into the water, because proteids must be acted on by the digestive juices before they can pass through a membrane. Some of the salt in the egg will have passed out into the water.

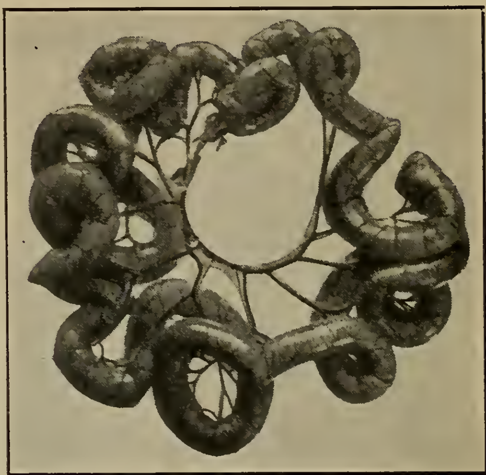


FIG. 65. — Part of the intestine, showing the veins taking the food from the villi to the liver.

How the Body uses Proteids and Carbohydrates. — Most of the proteids are used in rebuilding the worn-out tissues of the body, but some may be oxidized to produce heat. It is possible for a proteid to be changed into fat. The carbohydrates, before entering the blood, are all changed into sugar, which passes through the villi and veins to the liver. Here one part of it is changed into *animal starch*, called *glycogen*, and is retained until the cells of the body call for it. A second part of the sugar is carried to the muscles, and stored, while a third part circulates in the blood, and combines with oxygen to make heat. As oxygen combines with sugar more readily than with proteids, the sugar is used for heat and energy first, thus leaving the proteids for muscle repair.

FIG. 66. — Egg experiment, showing osmosis. The shell is removed from the egg at *m* so as not to break the membrane lying close within it. *a*, glass tube; *p*, paraffin; *e*, height to which the contents of the egg were forced in an hour.

Glycogen. — The form in which plants store up food is *plant starch*, as seen in the potato. *Glycogen*, or animal starch, is one form in which food is stored for use within an animal. After a meal rich in carbohydrates nearly ten per cent of the liver may consist of glycogen. After a period of rest one per cent of a muscle consists of glycogen, which is completely used up by an hour's exercise. An impulse sent through the nerve to the muscle causes the oxygen from the

blood to unite with the glycogen to produce the contraction of the muscle. It is the starches and the sugars, therefore, that furnish the energy-making stuff for a workingman.

How the Body uses Fats. — Fats pass into the villi in the form of fatty acids, soaps, and glycerin. These products then unite at once to form fat, which, by the lacteals and thoracic duct, is taken into the veins in the neck and thence to the heart (Fig. 64). From here it is sent with the blood to all parts of the body, where it is oxidized. This oxidation, or burning, makes heat to keep the body warm. It is for this reason that people in cold climates consume oils and much fat meat. When more fat than is necessary to furnish the required heat and energy reaches the tissues, it is stored in the connective-tissue cells to form the fat of the body. If too little food is taken at

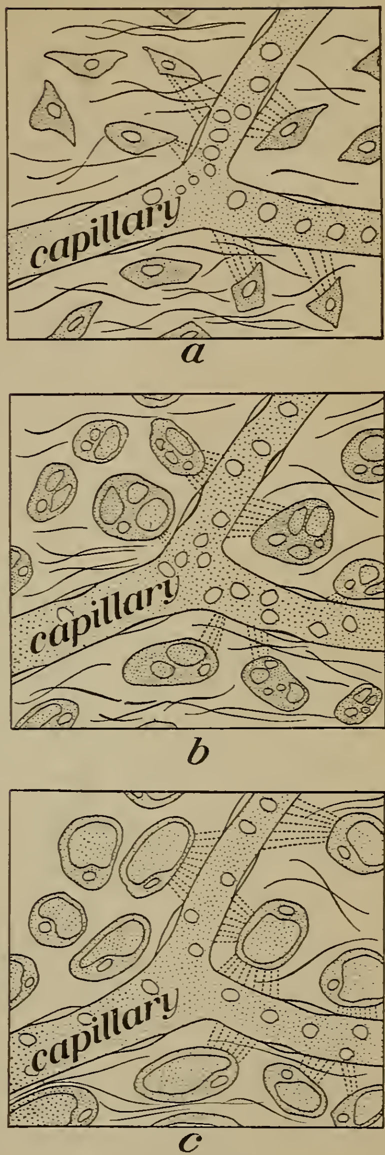


Fig. 67. — Connective-tissue cells changing to fat cells. *a*, fat passing from the blood vessel to the cells; *b*, where the fat forms two or three globules of oil in each cell; *c*, cells largely filled by a single oil globule.

any time, this stored-up fat is used to provide heat and energy.

How to make the Body Fat. — Some people are always fat, whether they eat little or much. In some cases, however, the amount of fat in the body can be controlled by diet and exercise. The fact that the eating of fat makes body fat has been shown by feeding a dog with mutton fat for a week, at the end of which time much mutton fat was found deposited in his tissues. That the carbohydrates are greater fat formers than fat itself has also been clearly demonstrated by feeding experiments. In order to become fleshy, therefore, one should eat a great deal of carbohydrate food, considerable fat, and enough proteid to take the place of the tissue waste. Rich milk, rice, potatoes, fat meat, olive oil, oatmeal, and soft-boiled eggs form a diet that will enable some persons to gain a pound or two weekly. An hour or more of daily exercise and ten hours of sleep in the open air are also of great help in increasing the body weight.

One who is too fat should live largely on lean meat, fish, fruit, and salads, and take plenty of exercise. No medicines advertised to make one fat or lean are of any value, and they sometimes produce serious results. The fat retained in the body is stored in the connective-tissue cells. These are named *fat cells* when most of their contents consist of fat or oil.

Alcoholic drinks tend to make the body fat, because alcohol injures the cells producing oxidation. The worn-out cells are not burned up and cast out in the excretions as they should be in health, but become fatty and hinder the work of the organs.

Questions

1. Where are ferments produced and what is their use? 2. How does saliva affect food? 3. Why should food be well chewed? 4. Give five points relating to the odor of food. 5. Why is the chewing of gum and tobacco generally harmful? 6. Explain the production of the gastric juice. 7. Describe the movements of the stomach. 8. Name the three foods most quickly digested. 9. Name the three foods requiring the longest time for digestion. 10. What frequently causes dyspepsia? 11. In what one part of the alimentary canal are all kinds of foods partly digested? 12. Describe the action of the pancreatic juice. 13. Of what use is the bile? 14. Why and how do the intestines move? 15. How is the food absorbed from the intestines? 16. Give the use of the lacteals. 17. Describe the portal system. 18. For what purpose does the body use lean meat? 19. Of what use are starches and sugars? 20. Explain the use of fats in the body.

Suggestions for the Teacher

1. Ask one of the boys to secure from the slaughterhouse a small piece of intestine or stomach. On the cut edge of this may be seen the mucous coat, containing the glands, and the muscular coat, producing the movements of the digestive organs. The villi are clearly seen only in the intestine of a dog or cat.

2. Ask some of the pupils to try the egg experiment, as shown in Figure 66.

XI. THE BLOOD

Parts. — The blood is composed of a colorless liquid, the *plasma*, in which float millions of round, platelike or cup-shaped cells called *corpuscles*. These are two kinds, the one being *red* and 500 times as numerous as the other, which are *white*. It is the presence of the *red* corpuscles which gives the color to the blood.

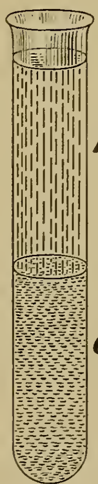


Fig. 68. — A test tube of blood, showing relative amounts of plasma, *p*, and corpuscles, *c*.

The Red Corpuscles. — These form almost half of the weight of the blood. About 25,000,000 are present in every drop of blood as large as the head of a pin. They are easily seen by examining with the high power of the microscope a smear of blood made by placing a drop on a glass slide and immediately drawing over it the smooth end of another slide held obliquely to the first.

Hemoglobin, the red coloring matter, is the most important part of the corpuscle. The *iron* contained in the hemoglobin enables it to carry oxygen from the lungs to supply the tissues in all regions of the body. The red corpuscles also transport about half of the carbon dioxide from the tissues back to the lungs to be cast out.

White Blood Corpuscles. — There is only one white blood cell to 500 red ones, and as it is colorless, it is not easily seen under the microscope unless stained with some dye. Some of the white cells are of the same size as the red ones, while others are more than twice as large. Many are capable of changing their shape very much after the manner of a little one-celled animal living in stagnant water and called the *amœba.* This amœba-like or amœboid motion of the white cells may be seen by examining with the microscope a drop of the fluid taken from a blister. This liquid is the blood plasma, with many white corpuscles which have leaked out of the minute blood vessels. The white cells creep through between the cells forming the walls of the capillaries in all parts of the body. In healthy tissues they are taken up by the lymph vessels to be carried back to the veins.

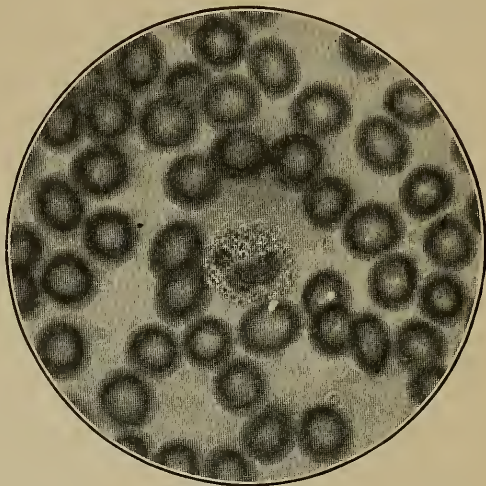


Fig. 69. — One white corpuscle and several red ones, photographed through the microscope.

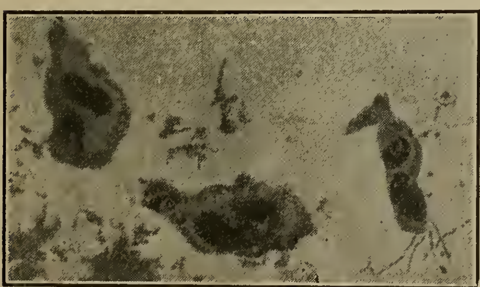


Fig. 70. — White blood corpuscles, photographed to show their form when crawling.

Wherever there is inflamed or diseased tissue, the white cells are attracted in great numbers. They creep out of the capillaries, and often large quantities are destroyed, and then they form most of the *pus*, or white matter, present in a boil or other suppuration. The white corpuscles have three uses: they aid the villi in absorbing certain food from the intestine; they have some part in causing the clotting of the blood; and they help protect the body from harmful germs by devouring them.

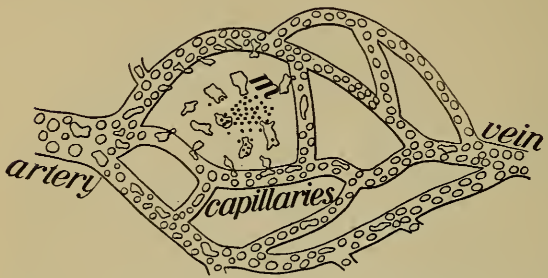


FIG. 71. — Diagram of a capillary network, showing the white corpuscles crawling through the capillaries to eat the bacteria, causing a boil at *m*.

Birth and Death of Corpuscles. — Since the coloring matter of the bile is derived from the dead red cells, and since millions of white corpuscles are being killed wherever pus is formed, there must be some

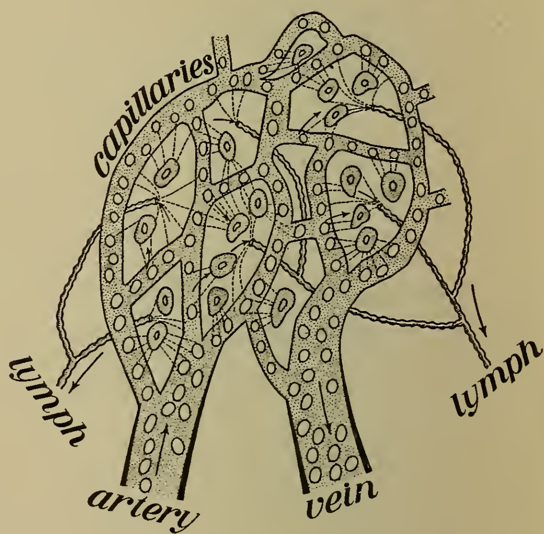


FIG. 72. — Diagram of the capillaries uniting an artery and vein. The plasma is passing through the walls of the capillaries to nourish the body cells, after which some of it enters the mouths of the lymph vessels and the rest returns to the the capillaries. Arrows show the direction of the circulation.

means by which new blood corpuscles are rapidly developed. The chief place of their birth has been found to be the red marrow contained in the ends of all the long bones, and abundant throughout the interior of the other bones. The small white corpuscles are derived from the division of cells in the several hundred lymph glands scattered throughout the body. Experiments on animals, in which millions of red corpuscles are lost by bleeding, show that they are regained so rapidly that more than a thousand must be formed every minute.

The Plasma. — This is the colorless part of the blood which is constantly filtering out of the capillaries for the purpose of supplying the tissues with food. While bathing these it not only gives to them nourishment, but receives from them ashes or waste products, such as carbon dioxide and that which becomes the chief solid in the urine. Then these waste products pass through the capillary wall into the blood, but the escaped plasma, which is not able to return to the capillaries, is now called *lymph*. Nine tenths of blood plasma is water.

The Lymph. — This is the blood plasma filtered and diffused from its vessels. It occurs in all spaces within the body cavity and in the crevices between the tissues. It contains numerous white blood corpuscles. Its purpose is to convey material to the tissues from the blood, and to the blood from the tissues. It is carried back into the blood system by thousands of microscopic vessels uniting into larger and larger vessels, of which two enter the veins in the neck.

The Use of Blood. — The blood performs four functions: It regulates the temperature of the body, transfers food to the tissues, bears oxygen to the tissues, and transports

waste matter from all regions to the organs casting it out of the body. The heat formed by the active cells in the deep tissue is carried by the blood to the minute vessels near the surface of the body, where the cool air and the evaporating perspiration have a cooling effect. The food is carried in the plasma of the blood to all parts of the body. A muscle cannot contract without oxygen, the vital organs refuse to act in the absence of oxygen, and the brain refuses to give orders if oxygen is shut off only for a minute. Therefore the distribution of this element by the blood is of prime importance. Life could not continue without the transportation of the waste products to the lungs, kidneys, and sweat glands for elimination.

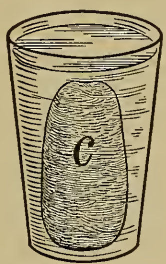


FIG. 73. — A glass of blood, showing the clot, *c*, floating in the serum almost filling the vessel.

The Clotting of Blood. — As soon as blood escapes from the vessels, it undergoes a change and becomes like jelly. This is called a *clot*. It is composed of all the corpuscles entangled in a white fibrous substance known as *fibrin*. The chief part of the plasma, much of which at first is contained in the clot, gradually works out, and appears around it as a yellowish fluid named *serum*. If blood is secured in a tall vessel from the butcher shop and placed twenty-four hours in a cool room, the serum will appear on top of the clot. There is no fibrin in the blood while in the body, but there is a proteid called *fibrinogen*, from which fibrin is formed in shed blood through the agency of a ferment not active in the blood vessels.

The fibrin may be easily separated from the clot by putting clotted blood into a muslin bag or enveloping it in a handkerchief, and then kneading or squeezing it five or ten minutes under water. The clotting of blood is very important, as by this means nature often stops the flow from a wound.

The Amount of Blood. — A full-grown person contains about six quarts of blood. Half of this quantity may be lost through a break in the vessels without causing death. When one has suffered the loss of much blood, the lack of fluid in the vessels is remedied by injecting a normal salt solution (7 parts of common salt to 1000 parts of water) into the veins. If pure water were used, many of the red blood cells would be destroyed, and the blood of another animal cannot be used because it likewise causes the red cells to go to pieces.

Pure and Impure Blood. — The blood carried in the arteries, except the artery leading to the lungs, is spoken of as pure or *arterial blood* because it contains very little carbon dioxide. It has a rich red color, while the blood of the veins, called *venous blood*, is of a bluish hue, as seen through the skin in the veins of the wrist. This color is due to the carbon dioxide gathered from the tissues. People who feel weak and languid or have pimples on the face are sometimes told that their blood is bad. Whatever the condition of the blood may be, it is due to the healthy or unhealthy state of the organs of the body, because the blood is made by the tissues and the impurities are removed only by certain organs. Therefore, when one is said to have bad blood, it means that the cells of some organ are failing to perform their task properly.

Bacteria in the Blood. — When the body is in health, no bacteria are present in the blood except just after a meal. The germs may gain access to the blood with the food taken in by the villi. This is a common occurrence in children. The bacteria present in the food of young guinea pigs have been found to pass into the blood in large numbers, while in older guinea pigs very few reach the blood. It is therefore important that one should not eat food containing disease germs, such as those of tuberculosis, sometimes found in milk and butter.

Harmful germs may get into the blood and yet no disease result, because the plasma has the power to destroy a few bacteria of almost any kind. This power may be greatly increased by the use of *vaccines* and *antitoxins*, so helpful in preventing smallpox, hydrophobia, diphtheria, and tetanus. The white corpuscles also destroy germs.

The Spleen. — The spleen is a dark red body somewhat oval in shape and much flattened, so that it is an inch thick and four inches broad by five inches long. It lies on the right side of the body in the abdominal cavity, and is partly covered by the ribs. Its function is not known. It enlarges very much a few hours after digestion, and probably has something to do in making a ferment to aid the pancreatic juice in digestion. It has no duct, and whatever its product is, it must go directly into the blood. In structure it is like the lymphatic glands, and it probably has a share in making some of the small white blood corpuscles.

The Thyroid Gland. — This is a flat two-lobed body weighing two ounces. It lies in front of the trachea below Adam's apple. It has no duct. A dog from which the

thyroid has been removed is able to live only three weeks. Persons from whom the thyroids have been removed on account of disease are kept alive by eating the thyroids of calves or pigs, or by taking an extract prepared from these glands. The exact use of the thyroid gland is not known, but its secretion is turned directly into the blood and has a marked effect on the mind as well as the general development of the body.

Questions

1. Name the parts of the blood. 2. Give five facts about red blood corpuscles. 3. What service do the white blood corpuscles render? 4. Where are the blood corpuscles formed? 5. How fast may corpuscles be formed? 6. What is the nature and use of blood plasma? 7. State what you know about lymph. 8. What are the chief functions of the blood? 9. When does blood clot? 10. How much blood does the body contain? 11. How does arterial blood differ from venous blood? 12. Give some facts in reference to bacteria in the blood. 13. Point out the location of the spleen on your body. 14. State the probable use of the spleen. 15. Give the function of the thyroid gland.

Suggestions for the Teacher

1. If possible, borrow a microscope and ask the lender to prepare a slide of blood so that you may show the corpuscles to the children.

2. Ask the class to observe the blood in the veins of the wrist, and explain why it appears blue.

XII. THE CIRCULATORY SYSTEM

THIS system consists of the *heart*, *arteries*, *capillaries*, *veins*, and *lymphatics*. The heart propels the blood, the arteries carry it from the heart, the veins and lymphatics return it to the heart, and the capillaries connect the arteries with the veins.

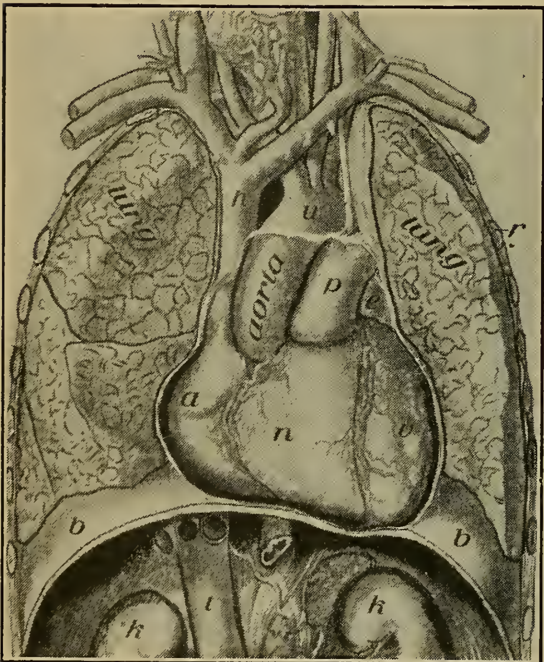


FIG. 74. — Organs of the chest. The front part of the pericardium is cut away. The lungs have been slightly separated. *a*, right auricle; *b*, diaphragm; *e*, left auricle; *h*, vena cava; *k*, kidney; *n*, right ventricle; *p*, artery to the lungs; *r*, one of the several cut-off ribs; *t*, vena cava; *u*, arteries to head and arms; *v*, left ventricle.

The Location of the Heart. — The heart, composed of involuntary muscle, is shaped like an egg and has its apex, or pointed end, directed downward and toward the left side of the body. It is surrounded by a tough membrane, the *pericardium*, containing half a teacupful of lymphlike fluid. This protects the heart from injury. It lies between the lungs and almost in the center of the

thoracic cavity, where it is held in place by the great blood vessels attached at the upper and back part, and also by fibrous tissue connecting the pericardium with the breastbone.

Fig. 75. — The human heart from in front. *a*, aorta; *ao*, aorta descending back of the heart; *c*, vena cava; *ca*, carotid arteries to the head; *e*, esophagus; *i*, left auricle; *m*, arteries to the arm; *p*, pulmonary artery; *r*, right auricle; *t*, left ventricle; *tr*, trachea or windpipe.

The Cavities of the Heart. — The heart contains four cavities, the two upper and smaller ones being called *auricles*, while the two

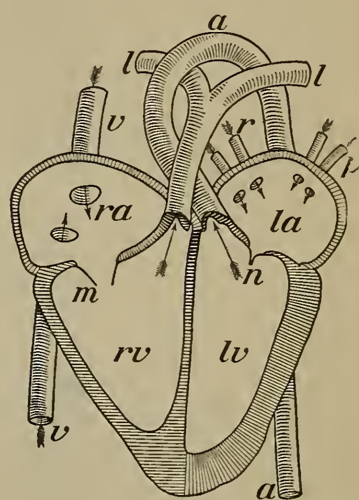


Fig. 76. — Diagram showing the front half of the heart cut away. *a*, aorta; *l*, arteries to the lungs; *la*, left auricle; *lv*, left ventricle; *m*, tricuspid valve open; *n*, bicuspid or mitral valve closed; *p* and *r*, veins from the lungs; *ra*, right auricle; *rv*, right ventricle; *v*, vena cava. Arrows show direction of circulation.

lower are named *ventricles* (Fig. 74). The auricles are thin-walled sacs which receive the blood from all parts of the body and pass it to the thick-walled ventricles, which send

it out to the tissues. The cavities on the left side of the heart are known as the *left auricle* and *left ventricle*, the other two being termed the *right auricle* and *right ventricle*. The muscular walls of the left ventricle are more than twice as thick as those of the right, because the one sends the blood all over the body, while the other sends it only to the lungs.

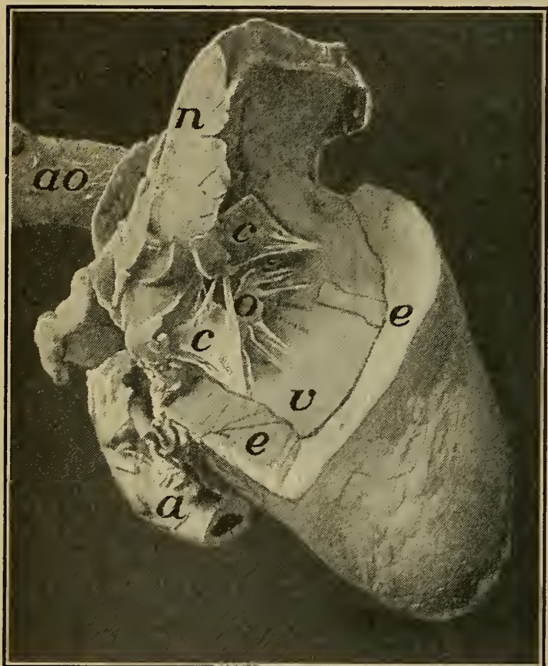


FIG. 77. — Calf's heart cut open. *a* and *ao*, arteries; *c* and *o*, parts of tricuspid valve; *v*, right ventricle; *e*, cut wall; *n*, cut wall held up by a stick.

The two openings into the right auricle are the *ascending vena cava* and the *descending vena cava*. There is no opening between the two auricles, but a large aperture guarded by valves permits the blood to pass from an auricle to the ventricle below it.

Four *pulmonary veins* open into the left auricle and bring the pure blood from the lungs. There is only one artery leading from each ventricle. From the left ventricle the *aorta*, a great artery larger than the thumb, carries the blood to the body. From the right ventricle the *pulmonary artery* extends to the lungs.

The Valves of the Heart. — In order that the blood may pass in only one direction through the heart, four sets of

valves are present. Between the right auricle and ventricle is the *tricuspid valve*, composed of three membranous flaps whose free edges are prevented from being pushed back into the auricle by the several tough cords, an inch or two long, extending from them to the walls of the ventricles (Fig. 77). The free margins of this valve, hanging down into the ventricle, permit the blood to pass from the auricle to the ventricle, which contracts and presses the blood against the lower surface of the flaps. This pushes them up and together, thus closing the aperture so that the blood must pass out of the pulmonary artery.

Fig. 78. — The pulmonary artery cut open to show the semilunar valves, *1, 2, 3*. *rv*, right ventricle.

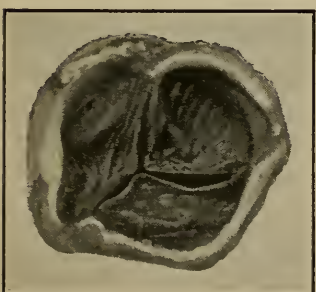


Fig. 79. — The aorta cut off at the heart, showing the three somewhat triangular semilunar valves closed.

The *mitral* or *bicuspid valve* guards the passage between the left auricle and left ventricle. It works in the same way and exhibits the same structure as the tricuspid valve, except there are only two membranous flaps.

In the mouth of the artery leading from each ventricle are three half-moon-shaped pieces of membrane attached by their convex sides only so that their free margins may be pushed out to prevent

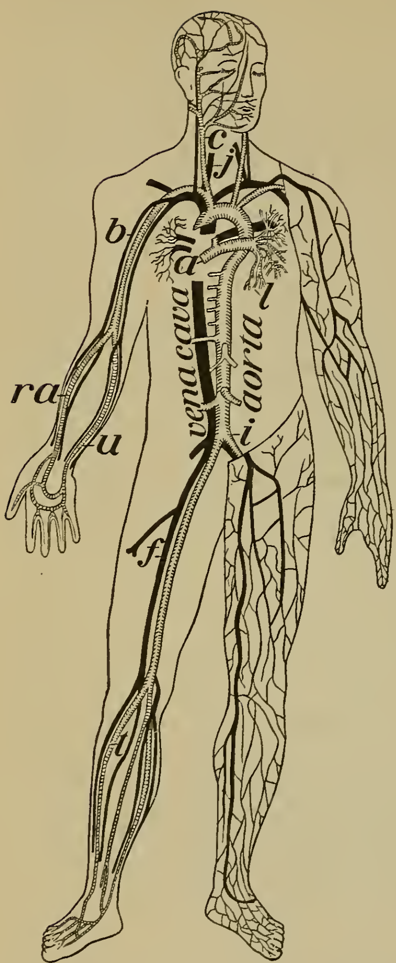


Fig. 80. — The chief blood vessels of the human body. On the left arm and leg the vessels are shown as they appear just beneath the skin. The veins are in black. *a*, location of the heart; *b*, brachial artery and veins; *c*, carotid artery; *f*, femoral vessels; *i*, iliac vessels; *j*, jugular vein; *l*, pulmonary vessels to the lungs; *ra*, radial vessels; *t*, anterior tibial; *u*, ulnar vessels.

the backward flow of the blood. On account of the shape of the parts, these valves are called *semilunar* (Fig. 79).

How the Heart Works. — The auricles are filled with blood at the same time, and then they contract and push the blood into the ventricles, which at once contract to send the blood out to the arteries. Then there is a pause of about a half second, while the heart is filling, before another contraction takes place. The contraction of any part of the heart is called a *systole*, and the pushing out of the walls while being filled is the *diastole*. The alternate contraction and expansion of the walls of the heart constitute the *heart beat*, which occurs about 75 times per minute in the adult and 140 times in the young child.

Exercise and the Heart. — The heart must beat faster during exercise in order to drive through the lungs a larger volume of blood to

secure enough oxygen to supply the demand of the muscles. Every muscular contraction uses up oxygen, and therefore the greater the exercise, the greater is the amount of oxygen needed. This need of the muscles is carried by the nerves to the spinal cord, where the proper cells send the order to the heart to work more rapidly. Prolonged and severe exercise, such as bicycle riding and running, if indulged in frequently, sometimes causes enlargement of the heart, resulting in serious trouble.

The Pulse. — The pulse is the wave of blood produced in the arteries by the heart beat. It may be felt wherever an artery runs near the surface, as on the thumb side of the wrist or just in front of the ear. Sickness usually affects the heart beat, because poisons are being generated in the body, and they act on the nerves controlling the heart. On this account, the frequency and strength of the pulse furnish the doctor with valuable information concerning the bodily health.

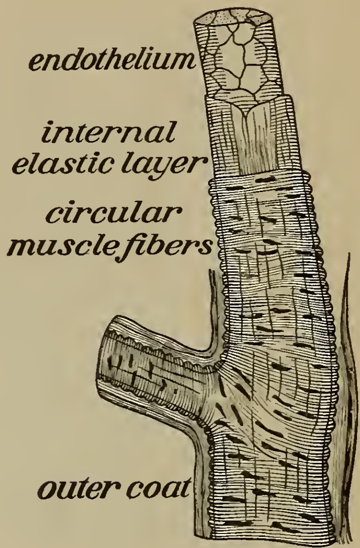


Fig. 81. — Small artery. Magnified. Part of the coats removed at one end to show structure.

Heart Disease. — Some form of heart disease is a common ailment in people over sixty years of age, and occasionally in those much younger. The census report of 1906 shows that more than 100,000 people died of heart disease in that year in the United States. Fatty degen-

eration of the heart, caused by the muscle being changed to fat, is likely to affect fleshy persons, and is especially prevalent among beer drinkers.

A most serious affection of the heart is the inability of the valves to prevent the blood from flowing backward. Disease of the valves often results from rheumatism, scarlet fever, and diphtheria. The medicines much advertised to cure heart ailments are of no use, and should never be taken by those who want to live. A physician should be consulted. The very rapid and irregular beating of the heart is spoken of as palpitation of the heart. It is frequently caused by some digestive trouble in the stomach.

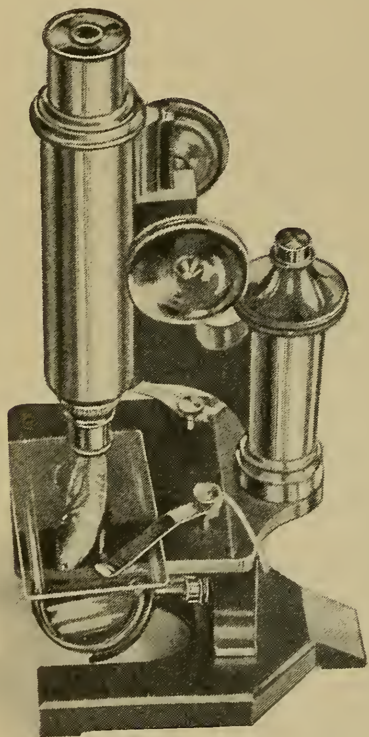


FIG. 82. — Microscope arranged to see the blood circulating in the tail of a tadpole.

The Arteries. — The vessels carrying the blood away from the heart are the arteries. Prior to the seventeenth century they were thought to conduct air, hence the name. They are empty after death, and the blood is found in the heart and veins. The walls of the arteries are much thicker and more elastic than those of the veins. They are made of elastic fibers, other con-

nective tissue, involuntary muscle cells, and a layer of flat epithelial cells within.

The chief artery of the trunk is the aorta, which leads from the left ventricle, and at once forms an arch to pass behind the heart down through the body cavity in front of the backbone. It gives off more than thirty branches to the trunk and the internal organs. In the lower part of the abdominal cavity it divides into a *right iliac* and a *left iliac* to supply the legs with blood. From the arch of the aorta three branches are given off to supply the arms, neck, and head. The large artery on either side of the windpipe is the *carotid*, taking blood to the head and brain.

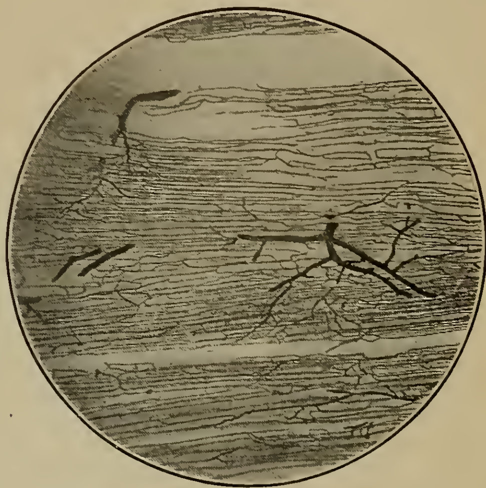


Fig. 83. — Arteries dividing into capillaries in a muscle. Photographed through the microscope.

The *pulmonary artery* is a large vessel leading from the right ventricle to the lungs. This is the only artery transporting venous blood. All the arteries branch again and again, like the branches of a tree, until the little vessels are too small to be seen with the naked eye.

The Capillaries. — The capillaries are the smallest blood vessels of the body and serve to connect the arteries with the veins. A capillary is about as long as the diameter of an ordinary pin, while its breadth is one fifth that of

a hair. From each terminal minute artery branch several capillaries, which reunite so as to form a network in all regions of the body. These vessels are so numerous that a needle cannot penetrate the flesh without piercing some.

The walls of the capillaries are made of a single layer of epithelium, so thin that the oxygen and food in the blood may easily pass through while the waste of the tissues enters the blood. The capillaries with the blood moving in them may be easily seen in the tail of a tadpole or a small fish on a large glass slip put under the low power of the microscope (Fig. 82).

FIG. 84. — Vein cut open to show valves. *i*, free edge of valve *v*.

Use of the Capillaries. — Arteries and veins merely conduct blood. The capillaries perform three functions: they connect the arteries with the veins; they allow the oxygen, some white cells, and some plasma to escape among the tissues; and they let waste matter pass from the tissues into the blood. Sufficient time is afforded for the exchange of these elements, as the blood flows very slowly through the capillaries.

The Veins. — The walls of the veins are much thinner than those of the arteries, but have a similar structure. They carry the blood to the auricles of the heart. The *venous blood* differs from the arterial in containing little oxygen and much carbon dioxide. The pulmonary veins, leading from the lungs to the heart, convey oxygenated blood. The two great veins of the trunk are the *descending vena cava*, bringing the blood from the head, neck, and arms, and the *ascending vena cava*, returning blood from

the trunk, the internal organs, and the legs. The large vein on either side of the neck is the *jugular*.

Within the veins, especially those of the extremities, are numerous *valves* permitting the blood to pass in only one direction. The arteries, except at their openings from the heart, do not have valves. By breathing and movement of the muscles of the trunk and limbs, the blood vessels are pressed on, and their contents are then forced toward the heart, because the valves of the veins permit the blood to flow in only one direction.

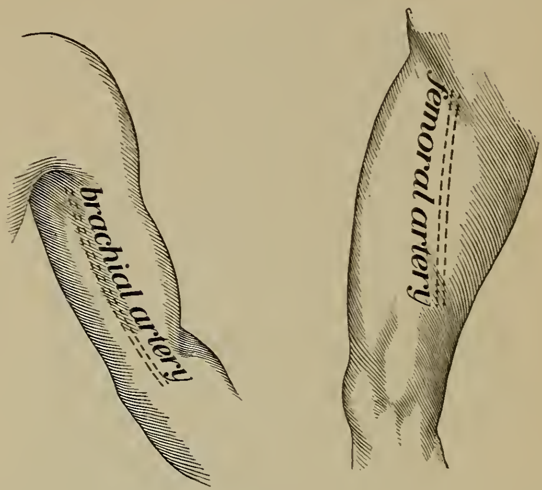


FIG. 85. — Regions where large arteries lie near the skin.

How the Blood Vessels are Named. — The names of the arteries and veins, as well as the nerves supplying an organ, are usually derived from the Latin name of the organ. *Brachial* is the name of the large vessels in the arm, *renal* applies to the vessels of the kidneys, *hepatic* to those of the liver, *cardiac* to those of the heart, *mesenteric* to those of the intestines, *radial* to those along the radius, and *femoral* to those along the femur.

Location of the Vessels. — Most of the arteries lie in protected places deep beneath the muscles. In the forearm and also in the leg below the knee, two or three

routes are provided for the blood to and from the extremities, as may be seen in the figures. The brain is a most important organ, and there are four different channels provided for carrying to it the blood from the large vessels in the chest.

FIG. 86. — *a* is bluing injected through the skin on a cat's ear, to show how from this lymph space the many tiny lymph vessels take up the blue material and pass it on to larger vessels.

In the limbs the chief veins, arteries, and nerves lie close together and usually near the bone. Another set of veins, known as *superficial*, lie just beneath the skin. These may be seen plainly in the arm.

Lymph Vessels, or Lymphatics. — There are numerous chinks and crevices among the tissues called *lymph spaces.* Large lymph spaces exist within the serous membranes of the thoracic and abdominal cavities. From all of these spaces the lymph is conveyed by minute vessels called *lymph capillaries.* They form a thick network in many parts of the body. They unite to form larger vessels, and these combine to form trunks, of which there are several

extending up each limb and downward from the head. Those from both legs, the left side of the body, neck, head, and left arm join the *left thoracic duct.* This is about the size of a lead pencil, and extends from the lumbar region along the back side of the body cavity to unite with the large vein in the neck. The trunks of the right side of the body, right arm, and right side of head and neck join the very short duct emptying into a vein on this side of the neck.

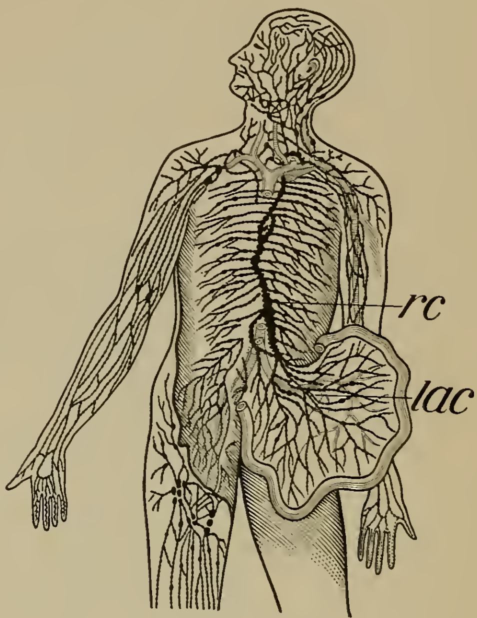


FIG. 87. — The lymphatics, or lymph vessels. The dark spots are lymph glands, or nodes. *lac*, lacteals; *rc*, thoracic duct.

Vessels also lead from the internal organs to the thoracic duct. Those extending from the small intestine are called *lacteals*, because in addition to the lymph they convey the fatty portions of the food, appearing white like milk. The purpose of the lymph vessels is to return to the veins that part of the blood which escapes from the blood capillaries.

Any substance injected beneath the skin will be taken up by the lymph vessels and rapidly distributed over the system. Vaccine germs and the poison from a snake bite are usually gathered up by the lymphatics, as are also the medicines administered by hypodermic injections.

Lymph Glands, or Nodes. — These are small, round, oval, or oblong bodies, some of which are no larger than the head of a pin, while others are a half inch in diameter. They occur most abundantly in the region of the neck and in a fold of the peritoneum, which holds the intestine in place. Other groups are found where the limbs join the body and behind the lungs.

No lymph is turned into the veins without first passing through one or more lymph glands, which tend to withhold the bacteria or other harmful substances from enter-

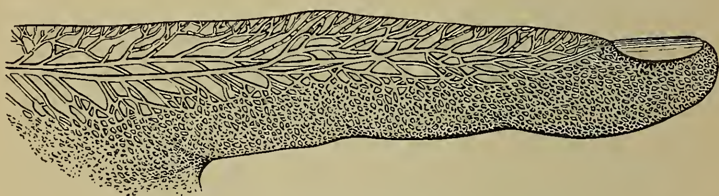


FIG. 88. — Lymph vessels of the finger.

ing the blood. A boil or other inflammation on the arm may cause many germs and so much poison to be carried to the glands in the armpit that they enlarge and become very tender in their effort to destroy these enemies to health. The lymph nodes are also of use in making some of the white blood corpuscles.

Cause of the Flow of the Lymph. — Lymph vessels filled with colored fluid may be recognized by their knotted appearance, due to the numerous *valves* which permit the lymph to flow in only one direction. The pressure of the lymph in the spaces about the lymph capillaries tends to force the fluid along in the vessels, and the pressing of a contracted muscle or even the filling of the lungs with air squeezes the lymph vessels and, on account of the

valves, moves the contents toward the veins. One of the greatest benefits derived from exercise is the freeing of the tissues from the lymph with its collected impurities. Massage produces somewhat the same effect as exercise.

The Course of the Blood. — The movement of the blood is from the left ventricle to the arteries of the body, then through the capillaries to the veins and lymphatics returning it to the right auricle. From here it goes to the right ventricle forcing it to the pulmonary artery into the lungs, where it passes by capillaries to the pulmonary veins conveying it to the left auricle opening into the left ventricle. The word v-a-v-a-c is an aid in remembering that the blood passes from veins to auricles and thence to ventricles forcing it through arteries to capillaries.

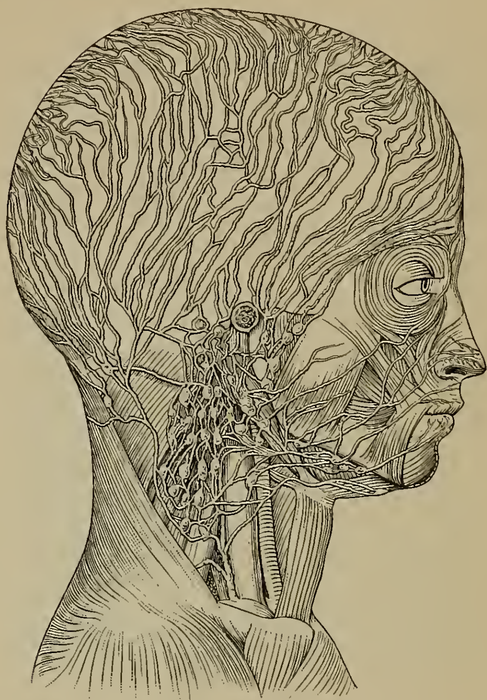


FIG. 89. — Lymph vessels of the head. Note more than a score of lymph nodes in the neck. (From the "Reference Handbook of Medical Sciences.")

The passage of the blood around through the lungs to the left auricle is called the *pulmonary circulation*, while its flow through the other parts of the body is known as the *systemic circulation*. A part of the systemic circula-

tion is called the *portal circulation.* This consists of the flow of blood from the capillaries and veins of the abdominal viscera into the portal vein and its branches dividing into capillaries within the liver.

Rate at which the Blood Flows. — The rapidity with which the blood travels has been determined by experiments on the lower animals. It passes through the largest arteries ten times as fast as through the very small ones, and flows less than one five-hundredth as fast in the capillaries as in the aorta. In the carotid artery of the horse it flows one foot per second, and it is estimated that it requires one second to pass through the entire length of a capillary.

Fig. 90. — Method of stopping the flow of blood from a cut by twisting tight a handkerchief under which a piece of wood has been thrust over the brachial artery.

Regulation of Blood Flow. — Since more oxygen is required during exercise, the blood must flow more rapidly to and from the lungs to supply the demand. The heart is made to beat more quickly by an order sent to it by nerve cells. These cells have been stimulated by the oxygen-hungry muscles sending a notice of their wants.

Hemorrhage, or Bleeding.— A blow on the skin often injures the small blood vessels, so that the red cells escape or the vessels become distended with blood, giving the place a bluish black appearance. If the skin and vessels are broken, the blood pours out, and this is called a *hemorrhage.*

If an artery is cut, the blood issues in spurts corresponding to the heart beats, while from a vein the flow is steady. Unless the vessel is large, a clot will soon form and check the flow. The hand or a clean cloth held over the cut helps very much in the formation of a clot. The flow from an artery may be checked by pressing tightly on the vessel on the side of the wound toward the heart. A handkerchief or cord should be tied loosely around the limb between the cut and the heart, and where the vessel lies nearest to the skin. A stick or folded cloth is then to be slipped under the ligature and over the vessel, and the ligature then tightened by twisting it with a stick. To stop the bleeding from a vein, the pressure or ligature should be applied on the side of the wound away from the heart.

A quart of blood may be lost by an adult without danger, and twice that amount may escape without causing death.

Circulation and Health. — Any wearing apparel which hinders the free circulation of the blood should not be used. Garters that encircle the leg and tight clothing about the waist are detrimental to health. When lymph collects in the tissue spaces faster than it is removed, a disease known as *dropsy* results. Exercise for an hour daily is necessary to promote circulation in health.

Alcohol and the Circulatory System. — A glass of beer or a glass of wine has a perceptible effect on the circulation. The arteries of the skin become enlarged and the extra blood sent to the surface produces the redness in the face. This is often constantly present in persons using alcohol daily. Since so much blood is near the surface, where the cold air may carry off the heat, alcohol in cold weather makes the body colder. A drink of whisky in winter may cause a man to feel warm, because much blood is forced into the skin, where the sense of heat is most acute, but a thermometer shows that the body throughout becomes colder. The experience of arctic travelers proves positively that those using alcohol in severe weather are the ones who soonest freeze to death.

The investigations of the Committee of Fifty, composed of well-known business men and scientists, show that in those who drink large quantities of beer enlarged hearts are comparatively frequent. The use of beer is a prominent cause of *fatty degeneration* of the heart muscle. One in every sixteen patients in the hospitals of Munich dies from enlargement of the heart, due to the drinking of beer. In habitual drunkards the coats of the arteries are liable to become hardened, so that a little extra pressure will produce a rupture. The breaking of a vessel in the brain often results in *apoplexy* or *paralysis*.

The elements in the blood warding off all kinds of germ diseases are weakened in those using much alcoholic drinks, so the chances of life are greatly in favor of total abstainers. A recent publication of the Committee for the Prevention of Tuberculosis in New York states: "Alcoholism is admitted by all authorities to be an im-

portant factor in predisposing to tuberculosis. Liquor as a beverage is never useful and nearly always harmful. Alcoholism must be considered the greatest enemy of the welfare of a nation, the most frequent destroyer of family happiness, and certainly the most active coöperator of the deadly bacillus tuberculosis."

Questions

1. Point out the location of the heart on your own body. 2. In what way do the cavities of the heart differ? 3. Describe the pulmonary veins. 4. Describe the valves of the heart. 5. Explain how the heart works. 6. How many times per minute does your pulse beat after running? Wherein do the arteries differ from the veins? 7. Name four arteries and tell to what parts they lead the blood. 8. Describe the capillaries. 9. Name the largest vein and largest artery in the body. 10. According to what plan are the arteries and veins named? 11. Describe the largest lymph vessel. 12. How does lymph of the finger reach the blood system? 13. What causes the flow of lymph? 14. Describe the course of the blood through the body. 15. At what rate does the blood flow? 16. Explain how a hemorrhage may be checked. 17. In what way does exercise benefit circulation? 18. What effect has alcohol on the blood vessels? 19. How does alcohol affect the heart? 20. State the influence of alcohol on the blood.

Suggestions for the Teacher

1. Ask a boy to secure from the butcher or slaughterhouse the heart of a sheep, pig, or calf. Request the butcher to leave in place an inch or two of all vessels attached to the heart. Arteries may be distinguished from the veins by their thickness. Note the soft, small, and thin-walled auricles at the top of the heart and the veins entering them from the back. Cut a large piece out of the front side of each auricle and ventricle to show the valves. Slit open the pulmonary artery at its junction with the heart, and observe the three semilunar valves. This specimen may be preserved in the formaldehyde solution.

2. Ask a pupil to show how to stop the flow of blood in case a large artery is cut in the wrist or a vein in the arm.

XIII. THE RESPIRATORY SYSTEM

The Use. — The union of oxygen with any substance produces heat. The burning of wood is the union of the oxygen of the air with the carbon of the wood. In the same way the body is kept warm by the union of breathed-in oxygen with the food or tissues in the system. Moreover, energy or power to act may also be produced by the union of oxygen with another substance, as seen in the locomotive, where steam is formed from water heated by fire. Fire is the *oxidation* of the fuel. The oxygen, uniting with the dead tissues, burns them to ashes, so that they may be carried out of the body. Depriving the brain of oxygen causes fainting or unconsciousness.

In many worms and salamanders the oxygen needed passes through the thin, moist skin to the blood, while in all insects there are along the sides of the body several openings from which tubes branch like a tree among the tissues to convey oxygen. Oysters, fish, and many other creatures dwelling in the sea have *gills* for absorbing the oxygen contained in the air lying between the particles of the water. In the higher animals lungs are the only means of procuring oxygen for the system. The respiratory apparatus also serves to get clear of the carbon dioxide, which is a part of the ashes resulting from oxidation. Speech is likewise dependent upon the organs of respiration.

The Parts. — The respiratory system consists of the *nasal passages*, the *pharynx*, the *larynx*, the *trachea*, and

the *lungs*. The nasal passages are the two channels within the nose. The *pharynx* is the irregular cavity at the back of the mouth. The *larynx* is the cartilaginous box at the top of the *trachea*, or windpipe conducting air to the lungs (Fig. 51).

The Nasal Passages. — These two air channels of the nose are separated by the *nasal septum*. They open behind at the upper and back part of the mouth. They are lined with mucous membrane, in which are glands giving out a secretion called *mucus*. This is sometimes watery, as at the beginning of a cold, or thick and stringy, as when one is recovering. The mucus is of great service in preventing disease, as it has the power to destroy most germs. Thousands of these are caught daily on the hairlike processes, called *cilia*, sticking out from the surface of the cells. The numerous hairs in the passages also aid in holding back the germs and dust from entering the windpipe. Because of these facts one should breathe through the nose and not through the mouth, which has no special structures for restraining the dust and germs from the lungs.

The *nasal duct*, extending from the inner corner of the eye obliquely through to the nasal passages, permits the tears, constantly being secreted, to escape without running down the cheek. In case of weeping, the duct is too small to convey the many tears, and so they overflow. The nerve of smell is distributed to special cells of the mucous membrane in the upper part of the passages.

The Pharynx. — This is the large cavity at the root of the tongue, formed by the union of the nasal passages and the mouth. From the front and upper part of the

pharynx a *Eustachian tube* leads to either middle ear. From its lower part open the esophagus and larynx. On either side of the root of the tongue is an oval body nearly an inch long, called the *tonsil* (Fig. 91). Its use is not known, and it is often removed by the doctor when it becomes enlarged, as is the case in many children.

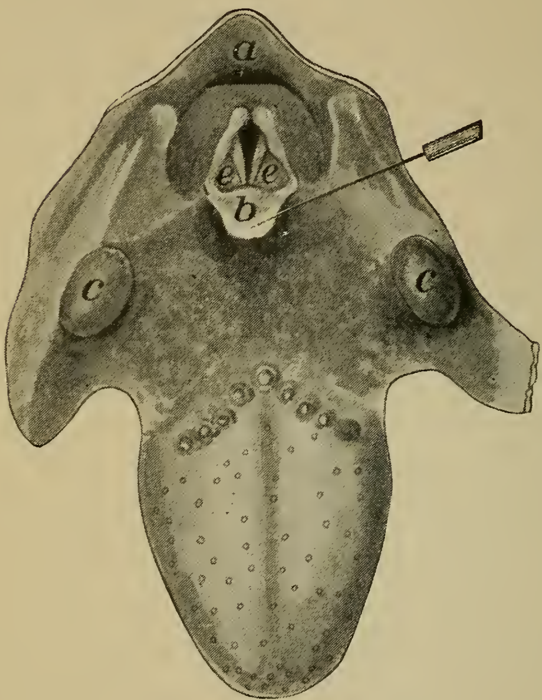


Fig. 91. — The tongue and opening into the larynx, seen from above. *a*, opening from pharynx to esophagus; *b*, epiglottis pushed forward with a needle; *c*, tonsil; *e*, vocal cords, between which is the opening to the larynx.

The *uvula* is a small finger-like body hanging down into the pharynx from the *soft palate* which forms the roof of the back part of the mouth. The *hard palate* is the roof of the mouth in front of the soft palate. Its mucous membrane lies against bone (Fig. 51).

The Larynx. — At the top of the windpipe is a tube about two inches long and an inch wide, made of two large pieces of cartilage and several small ones. The projecting part of the large cartilage, the *thyroid*, forms *Adam's apple*, the prominence in the neck under the chin. The cartilages are united by membrane and muscle.

Within the larynx is a layer of mucous membrane, whose surface cells have cilia projecting from them to catch and throw upward the germs and dust.

The narrow, slitlike opening from the pharynx into the larynx is the *glottis*. A small, somewhat triangular lid, the *epiglottis*, has its base attached just in front of the glottis. A projecting fold of membrane, passing from before backward on either side within the upper part of the larynx, forms the *vocal cords*.

The Vocal Cords. — These are two ligamentous folds of membrane, the ends of which are attached to the cartilage of the larynx (Fig. 91). The cords may be rendered more or less tense by certain muscles which may by contraction move the pieces of cartilage.

The stretching of the cords makes the passage between them small, so that the breathing out of air from the lungs causes them to vibrate and produce sounds called *voice*. When sounds are so modified by certain positions of the tongue, palate, teeth, and lips as to form words *speech* is produced. All animals from frogs to man have vocal cords, which may be easily seen by cutting a larynx of a calf or pig lengthwise from before backward. However, no animals except man can talk because they do not know how to use the organs of the mouth and throat in the right way to form the proper sounds.

The Voice. — The vocal cords are longer in men than in women, and therefore the women have a more shrill high voice. The longer the cords, the less frequently they vibrate when the air rushes out between them. The pitch of the voice depends upon the number of vibrations per second. The lowest bass note is produced by 44

vibrations per second, while the highest note, five and a half octaves above, is made by 1980 vibrations per second.

The loudness of sound depends largely upon the force with which the air is expelled through the larynx. In whispering, the opening between the vocal cords is so wide that the air passes out without causing any vibration, and the current is checked at intervals and modified by the lips, tongue, and teeth.

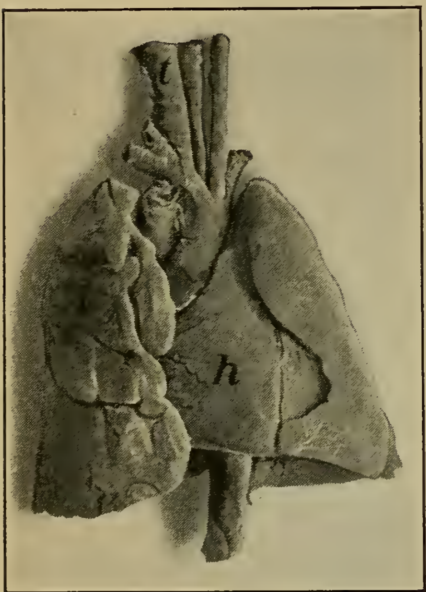


FIG. 92. — Human lungs. *h*, heart; *t*, trachea.

The quality of the voice, which differs so much in singers and speakers, depends not only on the condition of the vocal cords, but also upon the shape of the mouth, pharynx, and larynx, and their modification by the contraction of certain muscles. The *nasal twang* is produced when the nasal passages are partly closed by a cold or by a growth of tissue called *adenoids*. *Hoarseness* is due to a swelling of the cords, resulting from the blood and lymph collecting in them because of a cold or too long-continued use.

It is important that every one should cultivate a smooth and pleasant tone of voice and avoid making harsh and rasping sounds. The mouth should be well opened in speaking, the soft palate elevated, and the lips moved with firmness.

Some years ago deaf people who were unable to talk

except by making characters with the fingers were called *deaf* and *dumb*. They are not dumb, but their deafness prevents them from learning to speak by hearing. They can learn to talk, however, by observing how another holds the lips, tongue, and teeth when speaking.

The Trachea, or Windpipe. — This is a tube about an inch in diameter and four inches long, extending from the larynx to near the center of the chest, where it divides into two parts called *bronchi*. These branch to help form the lungs. Since the pressure of the muscles and the air have a tendency to push together the walls of the trachea, they are stiffened by more than a dozen *rings of cartilage*, incomplete at the back. Mucous membrane forms the inner layer of the trachea, and cells with cilia cover the surface and aid much in working all bacteria and dust particles up to the mouth.

FIG. 93. — Wax cast of the trachea of a cat, showing the branches of the trachea in the lungs. The trachea was poured full of melted wax, which became solid when cooled, and the lung tissue was then eaten away with acid. *t*, trachea; *b*, bronchus; *h*, bronchial tube; *e*, bronchioles. Blood vessels, black. (Preparation by Sylvester, of Princeton University.)

The Lungs. — There are two lungs, the left one being slightly smaller than the right. Both have their *bases* resting on the diaphragm, while the *apex*, or top, of each lies just back of the collar bone. Between them is the heart. The lungs are covered by a transparent membrane, the *pleura*, which also lines the thoracic cavity. *Pleurisy*, which is the soreness or inflammation of the pleura, is caused by the growth of germs on the membrane. These are carried there by the blood or lymph. The lungs are spongy bodies consisting of the two bronchi with all their tubular branches, enveloped by numerous blood vessels, nerves, air sacs, and connective tissue. The branches of each bronchus are named *bronchial tubes*. The smaller terminal branches beyond the bronchial tubes are the *bronchioles*, each of which ends in a group of air spaces, called *air sacs*. The walls of these air sacs are pushed out in a dozen or more places, forming tiny pouches called *air cells* (Fig. 94).

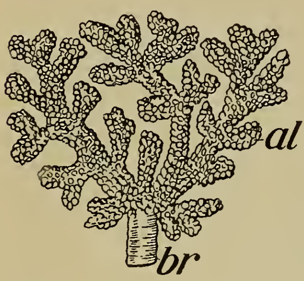


FIG. 94. — The termination of one of the thousands of bronchioles, *br*, like *e* in Figure 93. *al*, air sac with a dozen or more air cells.

The Air Cells. — In the lungs are millions of air cells, all of which form part of the walls of the air sacs at the termination of the tubes conveying air. By air cells is meant air spaces and not cells such as are spoken of through the body. The walls of the air cells are as thin as tissue paper and are covered with a network of blood capillaries. The oxygen breathed into the air cell as part of the air is thus able to reach the blood,

while the carbon dioxide passes from the blood to the air cell.

The air in the air cells must be constantly changed to keep up the supply of oxygen and to get rid of the carbon dioxide. This is done by the action of many muscles, producing an inward and then an outward flow of air through the trachea and tubes of the lungs. This process is called *breathing* and is necessary for respiration.

How Breathing is Maintained. — Breathing consists of *inspiration*, or inhaling air into the lungs, and *expiration*, or exhaling air out of the lungs. The air or atmosphere presses upon every object it touches in the same way as water presses on anything immersed in it. Air flows toward the place where the pressure is least. The pressure of air in a vessel or cavity may be decreased by increasing the size of the vessel or cavity and not permitting any air to enter.

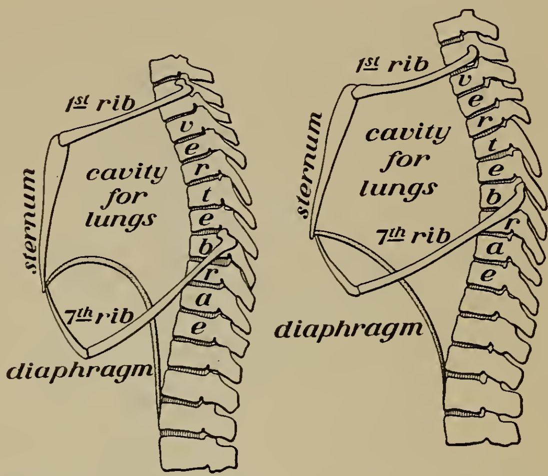


FIG. 95. — The position of the diaphragm and ribs when the chest cavity is enlarged to admit air into the lungs is shown at the right. The figure on the left shows how the chest cavity is decreased to push out the air from the lungs.

When the lungs are removed from the body of a mouse and placed in a bottle, with a glass tube extending from the trachea out through a hole in a tight rubber cork, and

the air then pumped out of the bottle, the lungs will expand. The air runs down the tube and presses out every air sac, thus filling the space that the air had occupied. During life air goes into the lungs when the pressure on the outside of the lungs is decreased by enlarging the cavity of the chest (Fig. 95). This decrease of pressure is produced by the contraction of certain muscles, and when these muscles are relaxed, the pressure of the ribs on the lungs causes the breathing out of the air.

How Breathing is Regulated. — Breathing occurs usually at the rate of about fifteen times per minute. During sleep it is slower; while violent exercise increases it to more than thirty times per minute. This is due to the fact that in sleep the tissues are more quiet, and therefore require little oxygen, while during exercise the muscles are consuming oxygen rapidly, and it can be supplied from the lungs only. When the tissues need oxygen, a message is sent to the cells of the spinal cord, which orders the muscles of the chest used in breathing to work faster.

Respiration. — Passing air in and out of the lungs is wrongly called respiration. True respiration is of two kinds: the *external* or *blood respiration* occurs in the lungs, while *internal* or *tissue respiration* takes place in the tissues all over the body. Blood respiration consists in the passage of oxygen from the air cells into the blood and of the carbon dioxide from the blood into the air cell. The air received into the lungs contains in every 10,000 parts 4 parts of carbon dioxide, 2096 parts of oxygen, and 7900 parts of nitrogen. When it issues from the lungs, there are 438 parts of carbon dioxide, 1602 parts of oxygen, and 7900 parts of nitrogen.

Tissue respiration consists in the giving up of the oxygen of the blood to the cells of the tissues, and the receiving of the carbon dioxide from the tissues into the blood. No cell can do its work without a constant supply of oxygen, and in doing its work some of the oxygen must unite with the carbon to form carbon dioxide.

FIG. 96. — Measuring the capacity of the lungs. The bottle was filled with water, which is being forced out by expiring the air from the lungs through the rubber tube slipped up into the mouth of the bottle kept under water in the pan.

The Capacity of the Lungs. — In ordinary breathing, only one pint of air passes in and out of the lungs. This is called the *tidal air*. In addition to this three pints of air may be breathed in by effort. This is *complemental air*. After the ordinary expiration about three pints of air, named the *supplemental air*, may by effort be forced out, but there will still remain some air in the lungs. This is *residual* air. The *vital capacity* of the lungs is the quantity of air that can be breathed out by the deepest expiration after the deepest inspiration. The usual amount is about four quarts for an adult.

Measuring the Lung Capacity. — Some idea of the capacity of the lungs may be derived by measuring the circumference of the chest after as much air as possible is

forced out, and then again measuring it after the fullest inspiration. The difference is usually from two to four inches. More accurate knowledge of the lung capacity may be gained by filling a gallon bottle with water, corking it, turning it upside down in a pan of water, pulling out the cork, and then by means of a rubber or glass tube

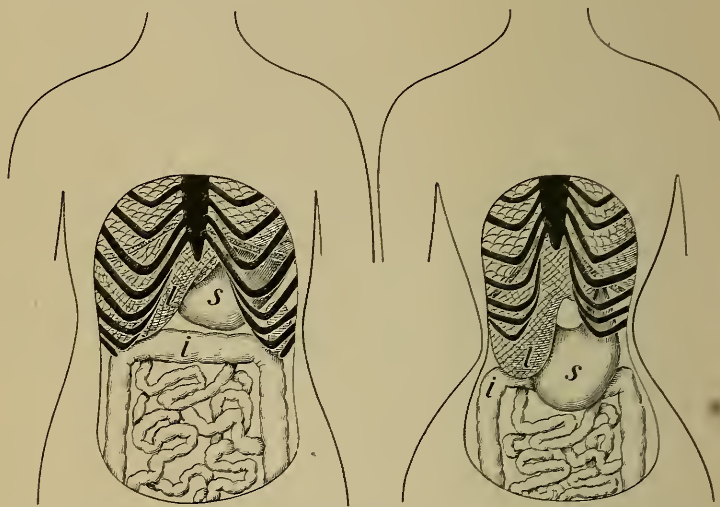


FIG. 97.—On the left is shown the normal position of the organs and on the right the effect of tight clothing worn around the waist. *l*, liver; *s*, stomach; *i*, large intestine.

slipped up in the neck of the bottle, blowing the fullest expiration of air into it. The air will force more or less of the water out. By measuring the water left in the bottle and subtracting the amount from one gallon, the vital capacity of the lungs may be known.

How Clothing affects Breathing.—In order that all parts of the lungs may easily be filled with air, both the diaphragm and the ribs must be free to move. Tight clothing about the waist not only hinders free respiration, but stops in some degree the circulation of the

blood, and worst of all presses the internal organs of the abdomen out of place. In this way serious ill health is often caused in later life. The evil results of tight bands worn about the waist, especially by young girls, frequently

FIG. 98. — Method of restoring breathing in a person partially drowned. This individual was unconscious about a quarter of an hour after being taken from the water. (From a photograph taken after recovery.)

continues to make the life of the victim miserable to its end.

Shortness of Breath. — The least exertion sometimes causes a person to breathe very rapidly. This may be due to heart disease or may result from tuberculosis having destroyed part of the lung tissue. Excitement frequently causes the nerves to send a message to the muscles forming part of the walls of bronchioles, and

makes them contract and shut off much of the air from the air cells. The catching for breath in case of *asthma* is due to the contraction of the muscles of the air tubes.

Modified Breathing. — *Sneezing* is a forced expiration, in which most of the air is made to pass through the nose. *Hiccoughing* is a sudden inspiration, caused by the quick contraction of the diaphragm. *Coughing* is a forced expiration, in which the larynx is suddenly opened wide. *Snoring* is an inspiration with the tongue and soft palate held in such a position as to make the air pass partly through the mouth and partly through the nose so as to produce a fluttering of the soft palate. *Whistling* is either an expiration or an inspiration with the lips so puckered as to cause a vibration of the air within the mouth.

Artificial Breathing. — The bite of a poisonous snake, electrical shocks, or partial drowning may cause the muscles controlling breathing to cease acting for a few minutes. If some artificial means are used to make the air pass in and out of the lungs for a few minutes, the nervous system may recover from the shock, and normal breathing again take place.

Of the several methods in use to produce artificial breathing that brought into use by Schaefer, in 1904, seems to be the most effective. The patient is immediately turned face downward, and a heavy folded coat, plank, or bunch of weeds is laid under the chest and upper part of the abdomen (Fig. 98). The operator then, standing astride and facing the head of the subject, places his hands, one on either side, over the lowest part of the

ribs. By slowly bending forward and thus pressing on the thorax, the air is driven out, and by gradually relaxing the pressure without moving the hands from their places, the air is drawn into the lungs. These movements should be performed about a dozen times per minute. A half hour is sometimes required to establish normal breathing.

Exercising the Lungs. — The lungs, when filled to their fullest extent, contain nearly five quarts of air. In ordinary breathing only about a half quart of air passes out and in. It is evident, therefore, that many of the air cells are not being used to their fullest extent, and under such conditions disease germs are more likely to set up growth. There is much evidence to show that consumption may be prevented, and in many cases even cured, by spending a few minutes several times daily in filling the lungs to their fullest capacity at every breath, and by living in the open air with an abundance of food.

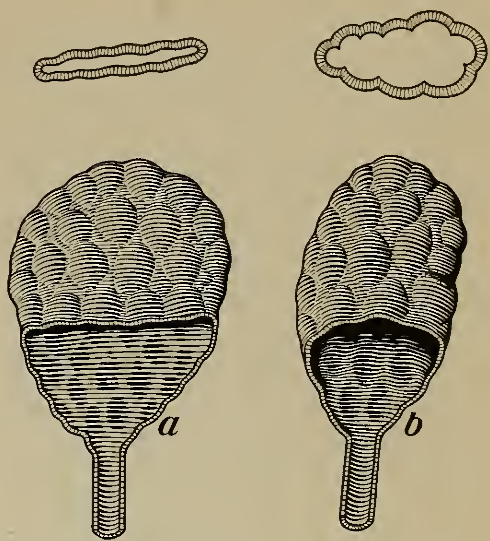


FIG. 99. — Air sacs at the end of air tubes in the lungs. *a*, from a lung not exercised; *b*, from a lung well exercised. The figures above are cross sections magnified.

Breathing exercises also cause the lymph with its collected impurities to pass on into the blood stream for purification by the kidneys and lungs. These exercises, practiced daily for three months, will often enlarge the

chest of a person under thirty years of age from one inch to three inches in circumference. If, when the lungs are full of air, the chest is beat lightly with the fists, the exercise is still more effective. Round and drooping shoulders and weak back muscles are corrected in a great measure by lung exercises together with the arm movements upward and downward, outward and inward, and forward and backward to their full extent.

Fig. 100. — Expression often present in children with adenoid growths in the back part of the nose.

Some Common Diseases of the Respiratory System. — Nearly all of the diseases of this system are due to germs. About one fourth of all deaths result from disease of the lungs. *Tuberculosis* kills over 4,000,000 in the world annually, and *pneumonia* destroys about as many in the United States as tuberculosis. The way for these two diseases is often prepared by *catarrh*, an inflammation of the mucous membrane. A temporary inflammation of the lining of the air passages, caused by germs overcoming the body cells when weakened by exposure, is called a *cold*. *Membranous croup* and *diphtheria* are diseases of the throat, produced by a special kind of bacteria often transferred from mouth to mouth by the drinking cup. Since the sputum coughed up from the throat and lungs may contain some

of these harmful germs, they should never be deposited on the sidewalk or on the floor of a car or a house. When dried, they will be blown about in the air, breathed, and thus make others sick.

Adenoids. — Adenoids are spongy growths frequently occurring in the back part of the nasal cavities of children. They interfere with the blood supply to the brain, clog up the nasal passages, cause mouth-breathing and indistinct pronunciation of words. Listlessness, inattention, poor memory, partial deafness, and frequent colds, or earache may result from adenoids. These structures are very common in children of school age. Signs indicating their presence are parted lips, prominent eyeballs, a narrow and high-arched roof of the mouth, and nasal speech. They are easily removed by a physician.

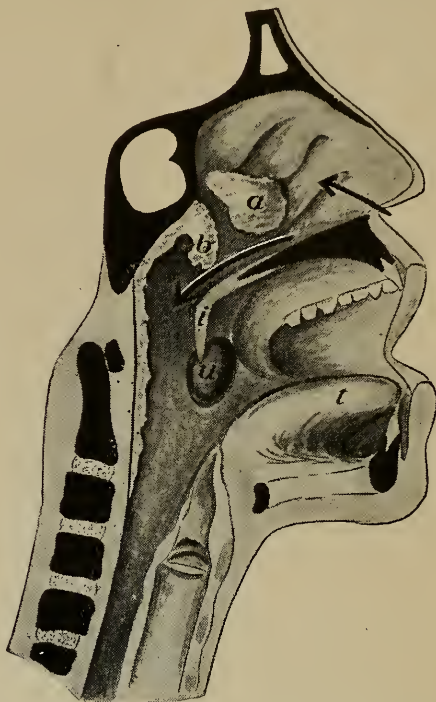


FIG. 101. — Section of the head showing adenoid growths *a* and *b*; *i*, uvula; *u*, tonsil; *t*, tongue. Arrows show the direction of the air.

Tobacco and the Respiratory System. — While tobacco affects more seriously the heart and nervous system, yet it also leaves its evil impress on the respiratory organs. The heat and gases, produced in smoking tobacco, tend to dry the mucous membrane and act as irritants to the throat, nasal passages, and larynx. After some years

those addicted to the chewing of tobacco or the smoking of the cigarette nearly always have a husky voice, due to the effects of tobacco on the vocal cords.

In *cigarette smokers* it is through the lungs that the poison chiefly reaches the blood. Those using pipes and cigars seldom inhale the smoke into the lungs, while over nine tenths of the cigarette users do. This permits the carbon monoxide, a poisonous gas generated from the burning of the tobacco, and the nicotine to pass readily into the blood and poison the nerves.

An examination for nine years of the boys in one of the large eastern colleges showed that the non-users of tobacco gained during four years in chest development 26.7 per cent more than the habitual users of tobacco. The continual use of tobacco decreases very markedly the lung capacity, as has been shown by many careful measurements taken at a New England college.

Alcohol and the Organs of Respiration. — One of the most constant effects of alcohol, especially if used in considerable amounts, is to lessen the rate and depth of breathing. In this way many of the air cells of the lungs fail to be expanded, and disease is invited. Of all the cases of tuberculosis in the New York Hospital on Blackwell's Island, one half are declared to be due to the use of alcohol. Dr. Crandall, in his book "How to Keep Well," states that users of alcohol are particularly liable to pneumonia. The United States Census Reports show that with the increased use of alcoholic drinks in this country there has been a marked increase in the number of deaths resulting from pneumonia. Physicians declare that the use of alcoholic drinks causes the death of a large propor-

tion of the three hundred thousand who die in this country yearly from disease of the respiratory organs.

Questions

1. Of what use is oxygen in the body? 2. How is oxygen supplied to the tissue? 3. Name the parts of the respiratory system. 4. Of what special use are the nasal passages? 5. Describe the pharynx. 6. What are the chief features of the larynx? 7. Describe the vocal cords. 8. How is voice produced? 9. On what do the loudness and the quality of the voice depend? 10. Describe the trachea. 11. Explain how the air tubes end. 12. Of what use are the air cells? 13. What causes the air to rush in and out of the lungs? 14. Why do you breathe quicker after running? 15. Explain what is meant by two kinds of respiration. 16. State some facts concerning the capacity of the lungs. 17. How does clothing affect breathing? 18. What causes shortness of breath? 19. Describe how artificial breathing may be produced. 20. Why is it important to exercise the lungs? 21. State five facts concerning disease of the respiratory system. 22. In what way does tobacco harm the respiratory system? 23. Give some evidence showing that cigarettes are harmful. 24. How does alcohol affect the respiratory system? 25. What is the evidence that alcohol does not prevent disease?

Suggestions for the Teacher

1. Procure from the butcher the lungs of a small pig or lamb. Pick loose with a pin some of the transparent glistening pleura covering the surface of the lungs. Slit open the trachea and bronchi, noting the mucous membrane lining them, and observe the numerous branches of each bronchus as it pierces deeper into the lung.

2. The larynx of a calf or other animal secured from the butcher will, when cut open from before backward, show clearly the vocal cords very similar to those in man.

3. By means of a gallon bottle and tube, as shown on page 141, ask several pupils to measure the capacity of their lungs and also the amount of air ordinarily expelled at a breath. This will tell them how much of the lungs is unused, and therefore in a condition to become diseased. See that the end of the tube put into the mouth is

well cleaned after each pupil uses it. A glass tube is preferable to rubber.

4. Have the pupils perform the following lung exercises: Standing erect, with shoulders thrown back, breathe in through the nose until the lungs are entirely filled; then exhale. Do this at the rate of a dozen times per minute for five minutes. For a few minutes, at the rate of thirty times per minute, swing the arms up and down from the sides of the body to above the head. Then, at the rate of forty times per minute, extend the arms forward in front of the body and draw them back until the closed fists strike the chest. During the next three minutes swing the extended arms forward so that the palms strike together in front of the body and then backward until they strike together behind the back. Explain that these exercises, practiced daily in the fresh air, are of great importance in warding off consumption and other diseases.

XIV. AIR AND HEALTH

Composition of Air. — Air is composed chiefly of the two gases *oxygen* and *nitrogen*, which are merely mixed and not combined chemically like carbon and oxygen in carbon dioxide. Because of this fact the blood is able to take up the oxygen only, without in any way affecting the nitrogen. The fact that there are four parts of nitrogen in the air to one part of oxygen may be shown by causing the oxygen in a jar to unite with the head of a match. About a fourth of a match bearing the head should be laid on a chip of wood or cork floating in a pan of water. After lighting the wood of the match with a taper, a glass is to be set over it just as the flame reaches the match head. The oxygen in the jar will be used up by the burning sulphur and phosphorus, and no more can get in on account of the water at the mouth of the jar. The white fumes formed from the burned-up oxygen will be absorbed by the water, which will then rise and occupy the same space before filled by the oxygen. By slipping

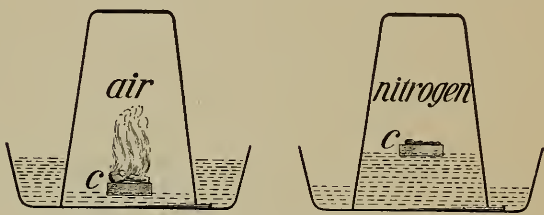


FIG. 102. — Experiment showing the amount of oxygen in the air. In the figure at the left *c* is a cork bearing a piece of match, which, by burning, used up the oxygen so that the water rose in its place, as shown in the figure at the right.

a piece of paper under the water and over the mouth of the glass, it may be turned up without allowing oxygen to enter. If the paper cover be then moved to one side a little and a burning stick thrust in, the flame will at once go out, because there is no oxygen present. There are about 4 parts of carbon dioxide in every 10,000 parts of air.

The Extent of the Air. — The air, or atmosphere, extends to a distance of ninety miles from the earth, and is present in the soil and the tissues of all plants and animals. Its presence in water makes it possible for fish to get oxygen by means of the gills, between which the water is continually passing from the mouth outward through the opening at the side of the head. At high elevations, as on mountain tops, the air is much less dense, and it is on account of the thinness of the air that ascent in a balloon above five miles proves fatal to the occupants.

The Source of the Air. — Billions of creatures are constantly using the oxygen to maintain life, and a new supply is continually being formed through the agency of plant life. All grass and trees or other plants of a green color give off large quantities of oxygen under the influence of sunlight. At the same time they use up much carbon dioxide breathed out by the animals. Plants use oxygen also in respiration, but they get during daylight much more oxygen than they can use from the carbon dioxide, and therefore set it free. Carbon dioxide and nitrogen are the two most important of all plant foods.

If a small candle is lit and put in a glass box having a space of twelve cubic feet, it will be extinguished in about one hour by the carbon dioxide given off. If

the same experiment is made again and the box is filled with large leafy plants, and exposed to the bright sun, the candle will continue to burn, because the carbon dioxide is consumed by the plants.

Gases pass to and from the plants through *breathing pores*, which appear in young apple and pear branches as minute white elevations smaller than the head of a pin. Breathing pores are more numerous on the leaves, but much smaller, so they can be seen only with the aid of the microscope (Fig. 103).

An acre of grass will give off enough oxygen on a

FIG. 103. — Surface of a leaf, showing eight breathing pores. Photographed through the microscope.

bright day to supply the wants of ten people at ordinary labor. The fact that plants do yield oxygen may be shown by placing a funnel over some water plants in the water exposed to bright sun, and running the tube of the funnel into a small vial filled with water. The oxygen may be seen rising in bubbles, and in the course of an hour enough of it will have collected in the bottle to be tested by a live coal on a burnt stick. If oxygen is present, the stick will burst into a flame when thrust into the bottle.

Impurities in the Air. — The commonest impurities in the air out of doors are dust and germs, some of which

produce disease. Only air far out over the ocean or on the top of high mountains is quite pure. During the first hour after a prolonged rain almost no impurities are present in the air of country places. The number of germs in city air during business hours and on dry days varies usually from 1000 to 10,000 in every cubic yard. By keeping the streets well sprinkled these numbers may be lessened more than four fifths. Dust and particles of soot, together with many germs, tend to make city life much less healthy than life in the country.

Foul Air. — This is air so full of gases from decaying matter or other sources that it has a bad odor and cannot be breathed long without affecting the health. The air of a room containing many people for an hour without ventilation becomes foul. In mines or deep wells carbon dioxide sometimes collects and causes quick death by suffocation to any one descending into them. It does this by preventing the red cells of the blood from getting enough oxygen to carry to the tissue. Foul air, such as that from sewers or cesspools, generally contains no germs, and therefore cannot convey to a person such diseases as diphtheria and typhoid fever, as some people suppose.

Night Air. — Until late years night air was considered unhealthy, because those who were out after night, especially in wet regions, were often attacked a few days later with *malaria*. It is now known that the malaria was not due to night air, but to minute animal germs transferred from one person to another by the bite of a certain kind of mosquito, in which the malaria germs live and multiply after the insect has sucked blood from a malaria

patient. One may sleep in the swamps and morasses in any part of the world without taking malaria if the mosquitoes are kept away by netting.

No one can get too much night air if he keeps warm. Night air has by analysis been shown to be much purer than day air, because the dust and germs settle to the earth when no one is about to stir them up. At night the windows of the bedroom should be kept open if one wishes to avoid colds, pneumonia, and especially consumption. During cool weather it is important that the head should be protected by a nightcap if there is any tendency to catarrh or sore throat. Sleeping in the night air has been one of the most efficient means used in curing thousands of cases of tuberculosis.

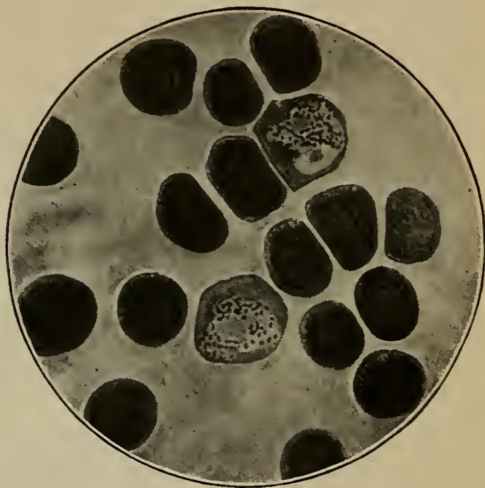


FIG. 104. — Two malaria germs each in a blood corpuscle. Photographed through the microscope.

Mountain Air. — Some people feel better when living in a mountainous region, and frequently those affected with lung disease are sent to the mountains to recuperate. The beneficial effect of mountain air may be due in part to the fact that it contains less germs and dust and is drier, but the chief benefit comes from the fact that the air is not so dense and the patient must exercise his lungs more to get the necessary amount of oxygen to feed the

tissues. It has been found that lung disease can be cured almost as well in any pure air if the patient will follow the physician's rules in reference to hygiene.

Seashore Air. — There is undoubtedly some element in the air along the sea not to be found inland. Certain forms of tuberculosis, especially that affecting the bones, get well in seashore air sooner than elsewhere. The seashore is also beneficial to sufferers from hay fever.

Respired Air. — This is air which has been acted on by the blood in the capillaries of the lungs and then expelled. It consists of about 80 parts nitrogen, 16 parts oxygen, and 4 parts carbon dioxide. This shows that the blood has taken up 4 parts of oxygen and given out in return 4 parts of carbon dioxide, while the nitrogen is in no way affected. Although germs are always present in the inspired air, no germs are given out in the expired air, even if the person is suffering from some disease. The germs are held fast on the moist mucous membrane. A sudden expiration, such as a cough or a sneeze, will, however, throw out many germs. As the expired air contains much more moisture and heat than that inspired, this is one way in which the body loses heat and water. A minute amount of organic matter is also present in respired air, and it is partly this which makes the air of unventilated rooms so unhealthy.

Need of Ventilation. — No one is expected to eat the food which has been once in his stomach or that of another and then cast out. Neither should one be expected to take into his lungs the air which has just come from them or from the lungs of some one else. This uncleanly habit, however, is common in most churches, schools, and

other public indoor gatherings. Ventilation, which means allowing the free entrance of pure air and the passing out of the impure air, is poorly provided for in most schoolhouses. As a result the children become listless and inattentive, and the teacher frets and scolds because of a weariness of the flesh produced not by work but by bad air. Boys and girls at school do not break down from overstudy, but from lack of exercise and fresh air. Living in closed rooms by day and sleeping without windows raised at night is a gentle way of committing suicide.

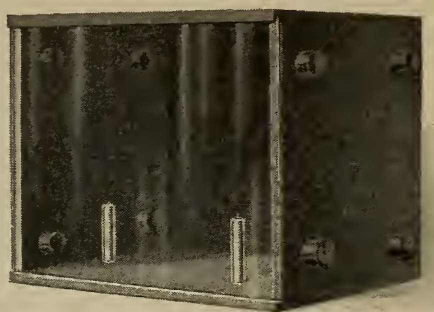


Fig. 105. — Experiment in ventilation. A pane of glass forms the front side of the box.

How to Ventilate. — Since the flow of cold air upon the body may make one ill, the fresh air must have inlets where it will not strike directly on any one in the room. Two or three windows all on one side of the room, pulled down several inches from the top and raised a few inches at the bottom, afford excellent ventilation. If a board, slanting inward, is placed in the bottom of the window so as to direct the current of air upward, no draft will usually be felt, even by those within a few feet of the window. The height of the board should be twice as great as the opening in the window, and triangular pieces at the ends will shut out the current tending to enter there.

To show clearly how to ventilate, a box with a small lighted candle, as in Figure 105, may be used. The candle

uses up oxygen, makes heat, and gives off carbon dioxide in the same way that people do. Four half-inch holes, bored in each end of a box with a capacity of 400 cubic inches, are fitted with corks and a pane of glass serves for one side. By removing the corks from one group of holes at a time, it is easy to determine which supplies the larger amount of air, as the candle flame goes up and down according to the amount of oxygen and carbon dioxide present. With all the corks in, the candle is extinguished in one minute. If two corks on the same end at the top are removed, the candle will burn two minutes. The removal of the two corks at the top in both ends allows the candle to burn three minutes, while if the corks are all in except two in the same end, one being out at the top and the other at the bottom, the candle will continue to burn until consumed. This is clear proof that only two openings, one low and one high, on the same side of a room afford

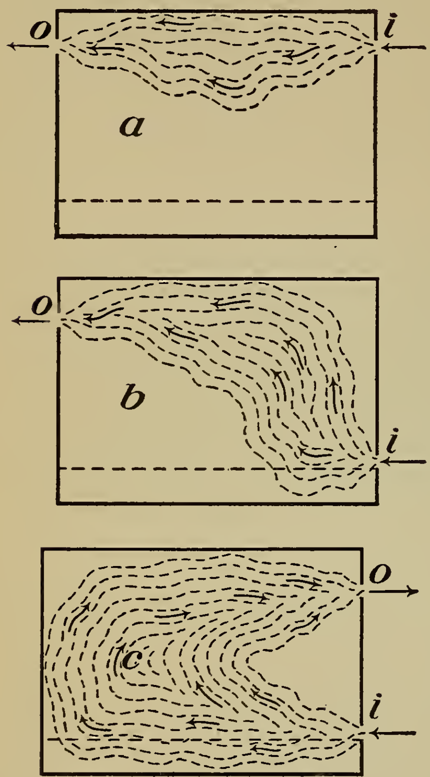


FIG. 106.—Diagram showing how to open the windows so that all pupils may have fresh air. The course of the air currents were determined by smoke and the brightness of the candles burning in different parts of the box. *i*, inlet for air; *o*, outlet for foul air. The dotted line is the level of the heads of the pupils.

better ventilation than twice as many opening at the top.

When a basement heater is used, plenty of fresh air may be furnished by leading it through a duct from the outside to the furnace to be heated and sent to the rooms above. On this account hot air is much more healthy than steam for heating purposes unless a special arrangement is made for supplying fresh air or drawing the impure air out by means of a fan. When air is forced into a room, it should enter near the ceiling, and an opening for the escape of the impure air should be on the same side of the room near the floor.

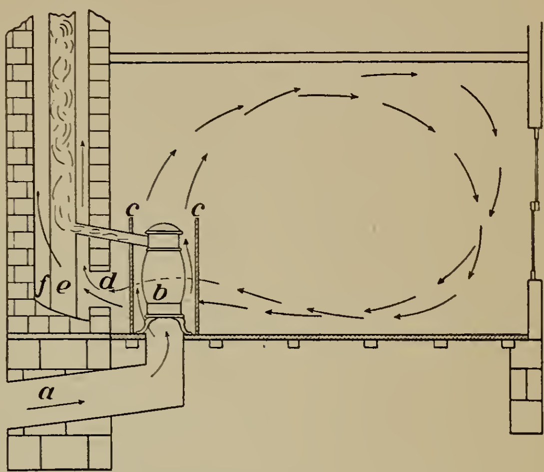


Fig. 107.—Section of a schoolroom heated by a stove. Arrows show the course of air currents. *a*, fresh air duct; *b*, stove; *c*, sheet iron jacket; *d*, outlet for impure air; *e*, smokepipe; *f*, flue for impure air.

The thousands of schoolrooms in rural districts where the stove is used may be well ventilated by adopting the plans shown in the figure. The stove is surrounded by a sheet-iron jacket standing off about six inches. The pure cold air enters through the duct beneath the stove, which warms it as it flows upward and then over the room, as shown by the arrows. Behind the stove is an opening into a brick flue for the escape of the impure air. This

flue extends above the roof and contains the sheet-iron smoke pipe, which warms the air and thus makes an upward draft. Good ventilation, with a pan of water on the stove to keep the air moist, will prevent much of the catarrh and colds from which children suffer.

One certain means of getting a supply of fresh air in a schoolroom is to have a few minutes' recess at the end of each hour and open wide the doors and windows. Prevention of ill health is better than curing it. Late investigations prove that fresh air is one of the three greatest preventives of disease.

Amount of Air Breathed. — At each breath an adult uses about 30 cubic inches of air, and as breathing occurs nearly 20 times per minute, 600 cubic inches of air are inhaled, making a total of 36,000 cubic inches per hour. The air of the schoolroom should never contain more than 7 parts of carbon dioxide in 10,000. To prevent the air from becoming impure, 2000 cubic feet of fresh air should be supplied every hour for each pupil.

Temperature and Moisture. — One cannot think well or work to his greatest capacity in a room that is too warm. If the room is too cold, illness may result. The most favorable temperature for a schoolroom is sixty-eight degrees. Overheated rooms cause many children to take cold in winter. Frequently the air of a room, on account of the heat, is so much drier than the atmosphere that it gives rise to a catarrh or inflammation of the mucous membrane of the nose and throat. The air may be kept moist by a pan of water set on the stove or radiator.

Sweeping and Dusting. — Rugs are preferable to nailed-down carpets, for they may be put out of doors in the sun

for cleaning. The dust may be then beaten out of them without settling in the room. Floors and furniture should be wiped with a damp cloth to which the dust and germs will adhere and not fly into the mouth of the cleaner. There is evidence to show that disease germs are present on the floors of all public buildings and of most houses in towns and cities. Care in cleaning means escape from sickness.

A short time ago the Upsala Street School of Worcester, Massachusetts, decided to throw away the old feather dusters and use moist cloths for dusting: as a result there was not a case of contagious disease in a school of 425 pupils during the entire school year. This condition of health had never prevailed before in the history of the school.

Disease and Air. — Dust-laden air and air in poorly ventilated rooms is known to be responsible for much of the illness affecting the respiratory system. Tool grinders, cement workers, and factory hands, breathing air laden with minute particles of matter cast off from the materials upon which they are working, are specially liable to lung diseases. All patients at sanatoria for consumption are compelled to remain practically out of doors night and day. Even with the thermometer twenty degrees below zero, one entire side of the room in which the patient sleeps is left open. More than half of those taking this fresh air, rest, and food treatment at the sanatoria in this country recover from their sickness. If fresh air will cure disease, it surely will prevent disease.

Questions

1. What is the composition of air? 2. How can you separate the nitrogen from the oxygen of the air? 3. What is the source of the oxygen of the air? 4. How can you show that plants give off oxygen? 5. Name some of the impurities in air. 6. Describe foul air and its effect on health. 7. Why should persons sleep with their windows open? 8. Explain fully how to ventilate a room in summer. 9. Explain how to ventilate a schoolroom heated with a stove. 10. How much pure air is required for each person per hour? 11. How do temperature and moisture affect health? 12. How may the air of a room be kept moist? 13. Why should nailed-down carpets not be used? 14. What is the effect of breathing much dust?

Suggestions for the Teacher

1. Prepare a cup of limewater by pouring slowly a half glass of warm water on a heaping tablespoonful of fresh lime. Five minutes later add to this a glass of water, stir well and pour it into a bottle which should be well corked. The clear liquid appearing in a day or two on top of the sediment is limewater. Put some of this into a cup, and with a glass tube let a child breathe a few times into the liquid. The white material resulting is calcium carbonate, formed by the union of the carbon dioxide of the breath with the lime. Place a dish of limewater and a lighted candle in a box for a few minutes, and note the result. Let some dishes of limewater stand an hour or two in rooms that are well ventilated and some dishes in other rooms not well ventilated, and note the result.

2. Ask some of the pupils to make a box for ventilating experiments, as shown on page 157. Show how poorly the candles burn when there is poor ventilation, and explain that the human body is weakened in the same way by an insufficient supply of pure air.

2. Demonstrate upon a pupil the method of producing artificial breathing and then require some of the pupils to continue the demonstration.

XV. ALCOHOLIC DRINKS AND THEIR EFFECT ON THE HUMAN RACE

How Alcohol is Made. — There are many different kinds of alcohol, each of which is produced in a different way. *Wood alcohol* is made by roasting wood and catching the vapors that pass off. The alcohol used in drinks is always produced by the growth of yeast in a liquid containing sugar. The *yeast* is an oval or spherical one-celled plant too small to be seen except under a microscope magnifying a hundred diameters.

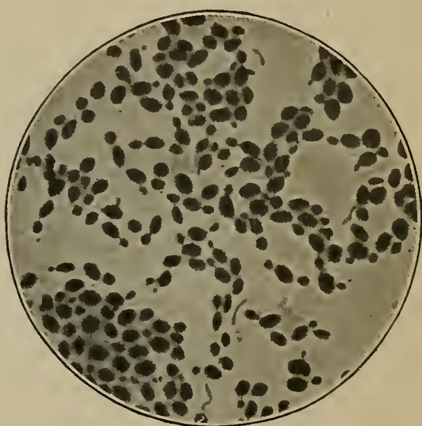


Fig. 108. — Yeast plants, many of which bear buds. Photographed through the microscope.

A yeast cake, such as is purchased at the store, contains millions of yeast plants. They multiply by budding. That is, a little projection pushes out on one side and continues to grow a half hour until it is the size of the mother plant. If a yeast cake is put in a glass of water in which a heaping teaspoonful of sugar has been dissolved, the yeast will grow rapidly when kept in a warm place. The chemical action produced by the growth is *fermentation*. In an hour or two the appearance of bubbles shows that

the growing yeast is separating the sugar into alcohol and carbon dioxide. This process is called *fermentation.* After it continues about six hours, the liquid will have a biting or sour taste, due to the alcohol formed.

Distillation.—In a sugar solution yeast will stop growing when the amount of alcohol formed is about one seventh part of the solution. This is due to the fact that alcohol tends to destroy life. In order to get a stronger solution of alcohol, such as whisky, this weak solution must be heated to near the boiling point in a vessel with a cork, through which passes a bent tube to another vessel surrounded by cold water. Heat causes the alcohol to pass over in the form of vapor into the vessel set in cold water. Here the cold changes the steam, or vapor, back to a liquid, which is a strong solution of alcohol. This process is known as *distillation*, and the alcoholic drinks so produced are called *distilled liquors*, or *spirits*.

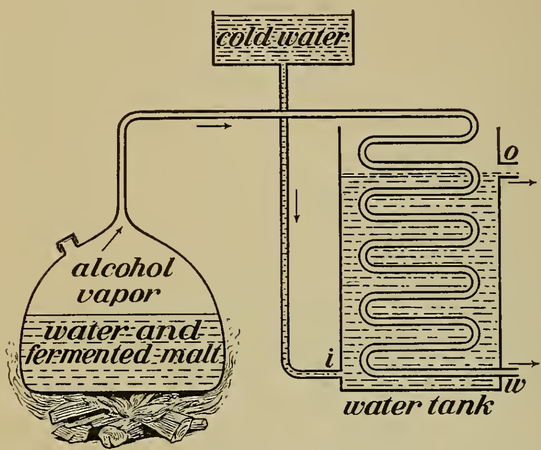


FIG. 109.—A simple distilling apparatus. *i*, inlet for cold water; *o*, outlet for cold water; *w*, outlet for alcohol.

Whisky is usually made in this country from rye or corn. The grains are sprouted in a moist warm room to change their starch into sugar. This product, when dried, is called *malt*. By mixing the malt with water and add-

ing yeast plants, alcohol is later produced. *Brandy* is a distilled liquor made from grape juice in which yeast has formed alcohol. *Rum* and *gin* are also distilled liquors.

Fermented liquors include all kinds of wine. They contain much less alcohol than the distilled drinks. They are produced by the growth of yeast in the juices of fruits, such as grapes and berries. *Malt liquors*, such as beer, porter, and stout, contain only a small amount of alcohol.

They are so named because of the malt, or sprouted grain, used to secure the sugar for the yeast plant to feed on. In fermented liquors the sugar from which the alcohol is formed is present in the fruit juice.

Amount of Alcohol in Liquors. — The strong alcoholic drinks composed of about one half pure alcohol are whisky, brandy, rum, and absinthe. The drinks of medium strength, containing from fifteen per cent to thirty per cent of alcohol, include many of the liquid patent medicines, gin, port wine, and sherry. The weak beverages, containing from three per cent to twelve per cent of alcohol, are beer, stout, porter, ale, champagne, cider, and many common red wines. Most of the *beer* made in this country contains about five per cent of alcohol, the ordinary *wines* have about ten per cent, and the best *whisky* contains fifty-five per cent. Apple cider, after standing three days in summer, may have as much as six per cent of alcohol.

Amount of Alcoholic Drink Consumed. — There are twenty-five times as much beer as wine consumed in the United States, and nearly twice as much whisky as wine. The quantity of beer used yearly by our people is over 1,000,000,000 gallons. So intemperate and beastlike does

alcohol sometimes render people that they frequently have no control over their appetites after taking a few drinks.

About $75,000,000 worth of patent medicines containing alcohol is sold yearly. Dr. A. P. Grinnell, who has made a study of this subject, declares that, with the exception of ale and beer, more alcohol is consumed in patent medicines than is dispensed by the licensed saloon. The value of all kinds of liquors produced annually is about a half billion dollars. To produce them 60,000,000 bushels of grain are used.

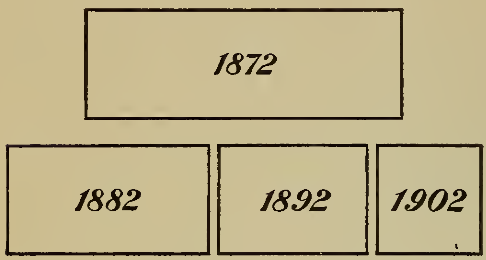


FIG. 110. — The sizes of the rectangles show how the use of alcohol has decreased each decade in seven of the large London hospitals while the number of patients has greatly increased.

Use of Alcoholic Drink Decreasing. — Owing to the education of the public concerning the evils of the drink habit, the consumption of strong alcoholic liquors has decreased greatly. In 1840, when nearly every family used some whisky, the average amount consumed for each inhabitant was two and a half gallons, while in 1896 the amount was only one gallon for each individual. A half century or more ago the labor organizations set aside money to buy liquor at their meetings. To-day many of the unions, such as the Metal Polishers, Core Makers, Iron Molders, and Knights of Labor, exclude any one engaged in the liquor traffic.

Recent investigations of the rules of many large business corporations brought forth the fact that

1794 of them prohibit the use of alcoholic drink by their employees. Hundreds of towns, many counties, and a few states have voted to prohibit the manufacture and sale of alcoholic drinks within their boundaries. It is unfortunate, however, that the quantity of beer consumed annually has greatly increased. This may be due in part to the fact that the people are not yet aware of the power of beer as a destroyer of health, home, and happiness.

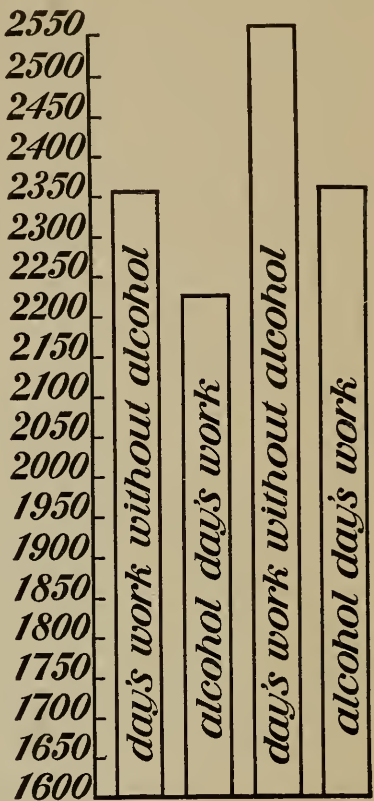


Fig. 111. — Diagram showing how a small amount of alcohol taken on alternate days affected a type setter. The figures at the left show the number of letters set up.

Alcohol in Health. — While it is possible for some older persons to drink small amounts of liquor daily for many years without apparent injury to themselves, yet experience shows that of those beginning the use of beer, wine, or whisky before the age of twenty-five a large percentage are injured in health by the alcohol. The recent report of the Committee of Fifty, known far and wide for its thoroughness and accuracy, furnishes evidence that about 1,000,000 men are every year drinking to such an excess as to cause evident injury to health.

The excuse often given for the use of these beverages

is that they help one to perform more work. The Committee of Fifty declares that the use of alcoholic drinks just before or during physical or mental work usually diminishes the total amount of work done. Dr. Woodhead, a professor in Cambridge University, writes as follows: "No amount of alcohol, however given, can increase the amount of work done in that same period without giving rise to very serious disturbances in some part or other of the body." Dr. T. G. Roberts says: "It was formerly thought that alcohol augmented strength, but it has been found by experiment that the man who drinks it cannot lift so heavy a weight as those who do not."

The habitual use of liquor has a tendency to weaken stomach digestion and decrease the value of food consumed. Dr. Brubaker, of the Jefferson Medical College, in Philadelphia, says: "Alcohol deranges the activities of the digestive organs, lowers the body temperature, impairs muscle power, diminishes the capacity for sustained mental work, and leads to the development of structural changes in the connective tissues of the brain, spinal cord, and other organs." Beer is often advertised as a nutritious drink, but analysis shows that it contains almost no nourishment. All scientists agree that in health beer, whisky, or wine should not be used for food.

Alcohol and Disease. — Very few, if any, persons can drink liquor daily without causing disease or a tendency to disease in some of the tissues. The Committee of Fifty, as a result of years of investigation, say that "the excessive and continued use of alcohol affects the liver, kidneys, heart, blood vessels, and nervous system." A considerable amount of the dyspepsia afflicting moderate

drinkers is due to the alcohol consumed. Most of the cases of shrinking and hardening of the liver result from alcohol. Excessive indulgence in alcoholic liquors is an important cause of Bright's disease, and in those who drink large quantities of beer diseased hearts are comparatively frequent. There are many cases in which alcoholic poisoning is evidently the cause of serious disease of the brain, spinal cord, and nerves. One result of beer drinking is the unhealthy production of fat which may occur among the muscle fibers of the heart. The use of wine and strong beer or porter may produce gout. The records of one of the large insurance companies show that those not using alcohol suffer a trifle over one half as many weeks' sickness annually as those who are not abstainers.

Physicians state that pneumonia and tuberculosis are much more likely to produce death in habitual drinkers than in others. The Committee of Fifty finally says: "The general conclusion is that fine old whiskies and brandies are nearly as likely to produce ill effects as the cheaper varieties."

Professor Welch, of the Johns Hopkins University, says: "Catarrh of the larynx, pharynx, and bronchi is common in alcoholic patients." The famous Dr. Weichselbaum, of Vienna, in speaking of the effects of alcohol on the body, says: "The blood gradually becomes sluggish in the different organs; namely, in the respiratory, digestive, and nervous systems. Such persons have an irregular weak heart, a chronic laryngeal and bronchial catarrh develops, and digestion becomes constantly poorer and slower; there are also brain and nerve derangements, due

not only to the stagnation of the blood, but also to the direct action of alcohol on the nerve cells."

Experience clearly proves that the persons soonest overcome with cold in winter or heat in summer are the users of alcohol. This is true because of the weakening or poisonous effect of liquor on the cells of the body.

Alcohol and Poverty. — While the use of alcohol does not always make one poor, records show that thousands of families in need of help owe their condition to liquor. A constant drinker, in addition to consuming several hundred dollars' worth of beer, wine, or whisky yearly, renders himself unfit to earn much money.

The Committee of Fifty, which spent much time and money to learn how much poverty alcohol caused, ascertained these facts: About one fourth of all cases of poverty brought to the notice of the Charity Organizations are caused by alcohol, and more than one third of the inmates of almshouses are brought there through the use of liquor. The presence there of two fifths of the males is due to alcohol. Of 5136 cases of destitute children over 2300 were found to owe their sad state to the use of alcohol by the parents. The annual report of the Bureau of Labor of Massachusetts shows that two fifths of all the paupers in the almshouses in that state were brought to that condition by strong drink.

Alcohol and Crime. — The wide and accurate scientific investigations lately completed by the Committee of Fifty proves beyond a doubt that alcohol not only wrecks the mind and body of thousands yearly, but also destroys character. The facts which they collected relate to 13,402 convicts in state prisons and state reformatories

in various portions of the United States. The first cause of crime in over 4000 of these was alcohol. Intemperance in over 6000 cases was one of the important causes of crime.

Police records show that over 1000 people are arrested every day in this country for drunkenness. No other offense results in so many arrests. In fact, drunkenness directly or indirectly results in more arrests in cities with licensed saloons than all other crimes combined. In one year there were arrested for drunkenness in Boston 24,000 persons, in Chicago, 31,164, in Philadelphia 24,661, and in New York 31,534.

National Loss through Liquor. — It is of course impossible to estimate the real value of homes, bodies, and characters ruined by strong drink. It is certain that over 10,000 convicts in our prisons have been brought there through intemperance, and over thirty per cent of the inmates of the almshouses owe their unhappy state to alcohol. The disease, suffering, and death due to liquor cannot be accurately computed, but the amount of money spent by the government and charitable organizations in caring for those poverty-stricken through drink is not less than $100,000,000. The time lost by the intemperate, if used in honest labor, would be worth at least $100,000,000, and the amount spent annually for drink is probably over $1,000,000,000.

Alcohol as a Medicine. — Many years ago nearly every family kept a jug of whisky in the house to be used in case of sickness. To-day very few educated people keep spirits in the home, because the latest scientific investigations show that neither whisky nor beer is of much if any value in curing disease. In most cases they make a

disease worse. People should never use patent medicines, as many in the liquid form contain from ten per cent to thirty per cent of alcohol or other injurious drugs. It is due to the stimulating effects of the alcohol that most of these medicines make the consumer feel better for a time. Many people have contracted the terrible alcohol thirst by taking patent medicines. Dr. Knopf, an expert of international reputation, says: "Alcohol has never cured and never will cure tuberculosis. It will either prevent or retard recovery."

Why Alcohol is called a Poison. — A poison is any substance which, when taken into the body in sufficient quantity, will produce sickness or death. A single spoonful of wine or a small glass of beer would not perhaps make any adult sick, and therefore would not be a poison. If this small amount were taken daily for some weeks, it would in some cases so change the tissues that there would be a continual longing for strong drink, and the craving might be so strong as to overpower the will. Under these circumstances the alcohol acted as a poison because it made some cells in the body sick. A small amount of strychnine or arsenic will not make one sick, yet we call them poisons. Whether alcohol is a poison or a food is of little consequence in judging its effects on humanity. The results of its use in any community are to increase crime, poverty, and death, and on this account the great statesman Gladstone said: "It is productive of greater evils than the combined scourges of war, famine, and pestilence."

Danger from the Use of Alcohol. — Some persons can drink beer or wine occasionally without perceptibly injur-

ing their health, yet their example may cause many to indulge who will be led on little by little until they become drunkards. Many who do not continue until drunkenness results, weaken their bodies and minds, and make themselves more liable to disease and crime. Reports secured from various parts of the United States show that at least one in every ten occasional drinkers becomes positively intemperate. Many people, after becoming accustomed to the use of alcohol, are unable to stop drinking without being placed in confinement and kept there until the tissues have again become well. The tissues of the young are affected much more quickly, and an incontrollable appetite developed much sooner than in persons past fifty.

The younger the individual the greater is the danger in taking an occasional drink. Helenius, in a paper read at the University of Copenhagen in 1902, showed that alcohol had fatally poisoned during the nineteenth century 7,500,000 persons in the civilized countries of Europe, America, and Australia. All of these were at one time occasional drinkers. Observation shows that the army of drunkards in this nation receives all of its recruits from those who are occasional drinkers. The one safe plan, then, is never to take the first drink. A young man can display no greater patriotism than to fight against that which brings to his country woe, want, and poverty. To be a total abstainer, that is, to refuse to use liquor at any time, requires the courage of principle that dares to do right in the face of scorn, a kind of courage that may be called the perfection of humanity.

Questions

1. How is alcohol made? 2. Tell what you know about the yeast plant. 3. Explain how distilled liquors are made. 4. Name some distilled liquors. 5. How do fermented liquors differ from malt liquors? 6. Name several malt liquors. 7. What drink contains the most alcohol? 8. Name some drinks containing a small amount of alcohol. 9. What drinks contain from fifteen per cent to thirty per cent of alcohol? 10. How much do our people pay yearly for alcoholic patent medicines? 11. What facts show that alcohol unfits men for doing their best work? 12. How many men in our country are drinking to such excess as to injure health? 13. Give evidence showing that alcohol does not enable one to do more work. 14. State ten facts showing that alcohol may produce ill health. 15. Why do not drinkers resist disease as well as abstainers? 16. Give facts showing that alcohol has much to do with poverty. 17. To what extent does alcohol contribute to crime? 18. How much does this nation lose through liquor? 19. When may alcohol be considered a poison? 20. Why is it not wise to take the first drink in youth?

Suggestions for the Teacher

1. Prepare three glasses with an inch of soil in each. Moisten the soil of number 1 with beer, number 2 with a solution of one teaspoonful of beer and two teaspoonfuls of water, and number 3 with pure water. In each plant several seeds of corn, wheat, or beans. Keep the glasses covered with a piece of glass, and place them in a light and warm room, but not in direct sunlight. Observe the growths during the following weeks, and ask the pupils to tell what the experiment teaches.

2. Secure two small potted plants of the same size, and for two or three weeks keep the soil of one moistened with water and the other with equal parts of water and beer. Note the results.

XVI. THE EXCRETORY SYSTEM

Excretions. — The excretions of the body such as sweat and urine differ from the secretions like gastric juice and saliva in that they are of no further use to the system. Every active cell is giving off several substances as a result of the life processes. The carbon dioxide is carried by the blood to the lungs, and through them is expelled. Waste flesh is constantly passing out of every living cell, and would in a few hours poison the body if it were not taken up by the capillaries of the circulatory system and transported to the kidneys and sweat glands to be separated from the blood.

Fig. 112. — Human kidney. *u*, ureter.

The Kidneys. — These are two bean-shaped organs a little longer than the middle finger. They lie against the posterior surface of the abdominal cavity, one on either side of the backbone just below the diaphragm. Any vessel or nerve distributed to the kidney is named *renal*, because the Latin word *renalis* means kidney. The renal artery comes direct from the aorta, and the renal vein leads the blood to the vena cava.

Within the kidney the artery divides like the branches of a tree, and each of the thousands of branchlets ends in a very tiny ball of capillaries. There are about a half million of these balls. Every one of them is enveloped by the enlarged end of a minute crooked tube, which unites with several of the thousands of other similar tubes to carry the urine to the inner edge of the kidney (Fig. 114). Here a somewhat funnel-shaped cavity, the *pelvis*, receives the urine and lets it pass into the *ureter*. This is a tube leading from the kidney to the *bladder*, a globular sac which is larger than the fist. It lies in the lower part of the abdomen.

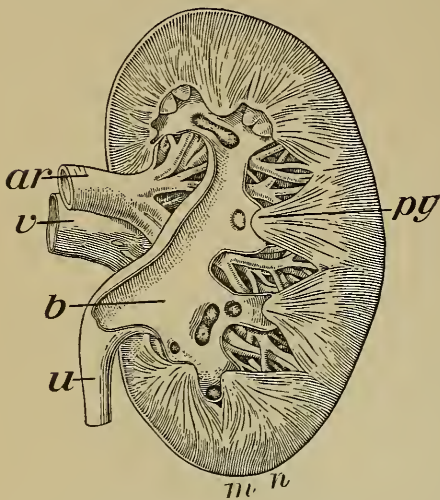


FIG. 113. — Section of a kidney. *ar*, artery; *v*, vein; *b*, pelvis; *u*, ureter; *py*, one of the several places where the thousands of tubes represented by the fine black lines empty into the pelvis.

How the Kidneys Work. — In the blood coming to the kidneys, there is much water, mineral matter, and waste flesh called *urea*. By the pressure of the blood and the living action of the kidney cells forming the fifteen miles of tubes, the water, salts, and urea are passed through the blood capillaries into the kidney tubes, and thence on to the pelvis, ureter, and bladder. Although the nutrition for the tissues is in the blood, yet the cells of the kidney tubes prevent it from being excreted, and cause to pass through them only that which would be harmful if left in the system.

Each cell seems to act with wonderful precision, and makes no error unless it is overworked or made sick.

The Kidney Excretion. — One twenty-fifth of the urine consists of solids, and the remainder is water. Of the solids more than half is composed of *urea*. The amount of broken-down flesh passing off from the system daily in this way is about one ounce. The more water one drinks, the more the kidneys excrete, and if one uses very little water, there is sometimes not sufficient fluid to wash properly the waste substances from the tissues and through the kidneys. Illness then results.

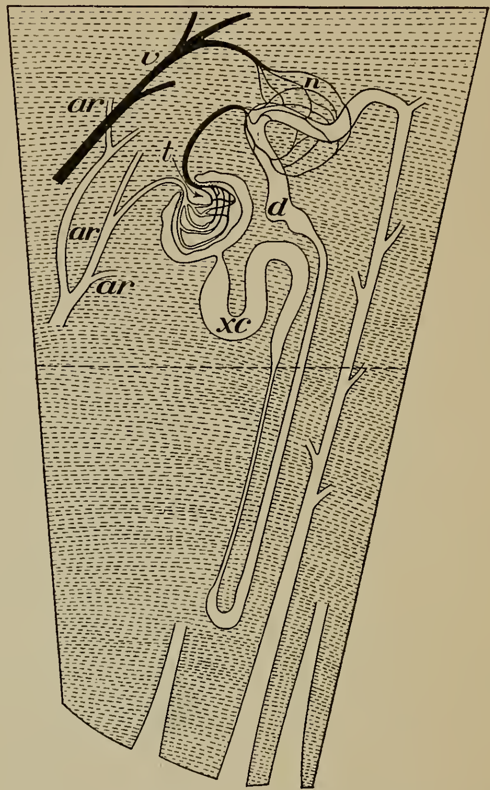


FIG. 114. — Diagram of the part of the kidney between the letters *m* and *n* in Figure 113. *ar*, artery; *v*, vein; *t*, ball of capillaries; *n*, capillaries. From these two sets of capillaries the urine is taken into the tube *xc* and *d*.

A good preventive of rheumatism, and constipation or clogging of the lower bowel, is the drinking of much pure soft water. A grown person should consume at least a quart of milk or water daily, and it would result in better health if two quarts of fluid were taken daily.

Alcohol and the Kidneys. — When the cells forming the tubes of the kidneys become sick, they allow part of the albumen of the blood to escape with the urine, resulting in serious ill health. This condition is known as inflammation of the kidneys, or *Bright's disease*. It is sometimes caused by alcoholic drink. It may also be brought on in some persons by eating too much meat or other nitrogenous foods for days and weeks in succession, while taking but little exercise. It sometimes follows scarlet fever and other diseases where there is a great deal of tissue waste which must be passed out through the kidneys. In any case the cells of the kidneys become sick because they are overworked. Bright's disease is twice as common now as it was a quarter of a century ago, and scientists agree that this increase is due in part, at least, to the increased use of the light alcoholic drinks. It caused nearly 100,000 deaths in the United States in the year 1905.

Structure of the Skin. — The skin is composed of two layers, known as the *cuticle*, or *epidermis*, and the *cutis*, or *true skin*. The cuticle consists of epithelial cells, the several upper layers of which have no nuclei and are flat. The deeper cells are cubical. No blood vessels or nerves are present, but every square inch is pierced by a hundred or more tubes leading from sweat glands. Under a magnifying glass, the mouths of these appear as minute pits arranged in rows on the little ridges in the palm of the hand. The cells on the surface of the epidermis are being constantly shed, while new ones are being developed from the lower layers. In caterpillars, crabs, frogs, and snakes the cells on the surface of the skin hold together

and are shed in one entire mass. The use of the epidermis is to prevent injuries to the more delicate structures beneath and to keep germs from entering the tissues.

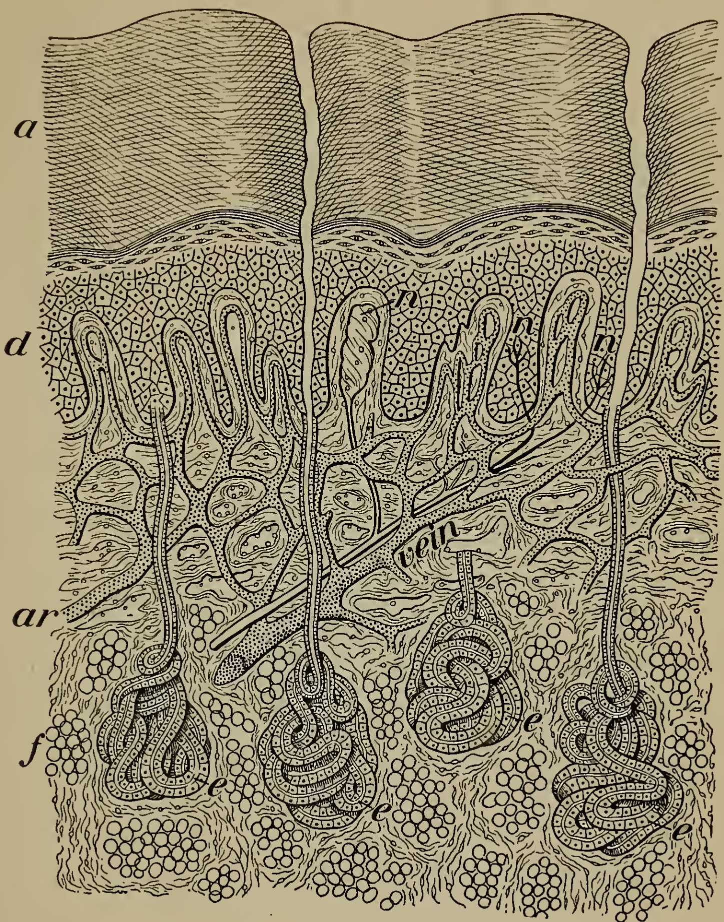


FIG. 115. — Section through the skin. *a*, dead epidermis; *d*, live epidermis: all below is the derma or true skin. *ar*, artery seen dividing into capillaries again uniting to form a vein; *e*, sweat glands; *f*, fat cells; *n*, nerve endings.

The *cutis*, or *derma*, lies beneath the epidermis and consists of a tough elastic network of fibers mingled with a few cells. In it are numerous capillaries and the end-

ings of nerves, some of which are acted on by heat, some by cold, and others by touch. The skin is bound to the underlying muscles and fatty tissue by a loose elastic connective tissue.

Use of the Skin. — The epidermis prevents injury to the more delicate structures beneath. Touching the naked nerve endings would cause pain, and contact with rough material would destroy them and break the delicate walls of the blood capillaries. This may be observed on any raw surface. The dry and horny nature of the epithelium excludes germs and poisons with which the body frequently comes in contact.

The *derma*, or *cutis*, is the seat of the important senses of pressure, pain, and temperature. We receive our knowledge of pressure and temperature entirely through nerve endings in the cutis, but nerve endings for the sense of pain are present all over the body. The cutis is also an important means of regulating the body heat. When the body becomes hot, the capillaries of the skin enlarge so that the hot blood can come to the surface and be cooled. Evaporation of the sweat also cools the body.

Injuries to the Skin. — Slight pressure or friction for a long time on the skin causes the epidermis to become thicker. For this reason it is more than twice as thick on the palms of the hands and the soles of the feet as elsewhere. Hard pressure or friction will sometimes produce a *blister* or a *corn*. A blister, which may also be made by the application of mustard or other irritating substance, is a portion of the epidermis separated from its deepest layer by a collection of lymph having oozed out of the underlying vessels.

A *corn* is a thickening of a spot of epidermis so that it presses on the tissues beneath. The best remedy for a corn is to soak the feet in warm water and then with a razor or sharp knife pare off the thickened cuticle, being careful not to cut deep enough to cause pain. The pressure of the shoe may then be removed by pasting on one side of the corn a piece of thick cloth with dried mucilage on one surface. Regular corn rings may be purchased at the drug store for the same purpose.

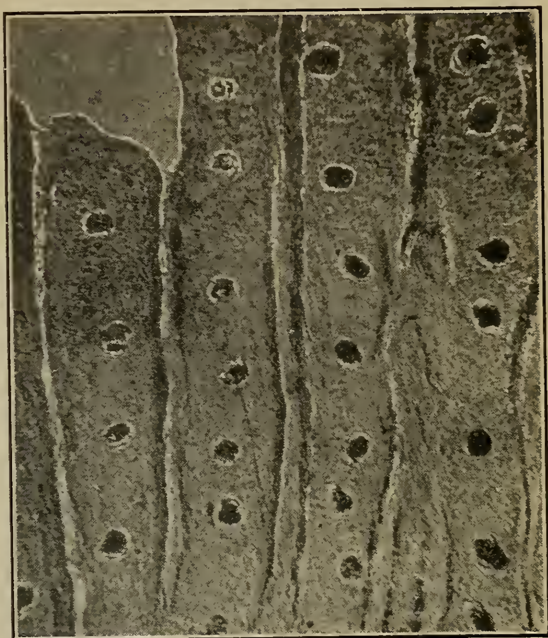


Fig. 116. — Mouths of sweat glands. Magnified.

Sometimes large areas of skin are destroyed by burning or otherwise. It is then necessary to cut small bits of skin from other parts of the body or from another person's body and lay them upon the raw surface. They will absorb the lymph diffusing from the capillaries, and the cells will multiply in a few weeks so as to cover the naked tissues. This is called *skin grafting.*

The Sweat Glands. — There are about 2,000,000 sweat glands distributed in the deeper layers of the dermis. They are thickest in the palms of the hands, on the soles of the feet, and on the forehead. Each gland consists of

a minute coiled tube in the cutis and a duct extending in a slightly wavy course through the epidermis to the surface (Fig. 115). With a magnifying glass these openings may be seen in the hand. These glands give forth a fluid called *perspiration*. Their activity is greatly increased by heat or exercise.

Perspiration. — The amount of sweat given out by a laboring man in warm weather may be as much as one gallon daily. The average quantity excreted by an adult is a little less than a quart in twenty-four hours. More than ninety-nine per cent of sweat is water. A slight amount of urea, common salt, and a few other substances are present. The chief use of the perspiration is to control the temperature of the body. Heat arouses certain nerves which control the sweat glands and makes their excretions flow out in larger quantities on the surface of the body. Here it evaporates and thus cools the skin. One seventh of the heat of the body is lost by the evaporation of the sweat. Dr. Zuntz tells of a man who had no sweat glands, and was unable to work in the hot weather because the temperature of his body became too high. Sitting in a wind after sweating often causes a cold.

The Sebaceous or Oil Glands. — These are present in the skin wherever hair occurs, whether it is long, as upon the head, or pale and short, as on other parts of the body. Each gland, scarcely as large as the point of a pin and somewhat like a bunch of grapes, opens by a single duct near the top of the sac inclosing the root of the hair. The secretion is an oily semiliquid mass which sets, upon exposure to the air, into a cheesy mass, as seen in the pimples frequently occurring on the face. These pimples

may be avoided in many cases by eating but little meat, refraining from sweets and pies, and taking much outdoor exercise.

The secretion of the sebaceous glands is of some use in keeping the skin soft and making the hair more pliable. It is, in fact, nature's hair oil, and no other dressing for the hair should be used. The glands may be made more active by massaging or gentle pinching of all parts of the scalp daily.

Fig. 117. — Section of the scalp, magnified. *h*, hair; *w*, hair sac; *s*, sebaceous gland; *m*, muscle which may sometimes cause the hairs to stand erect.

The Hair. — The hair is composed of minute horny scales and is widely distributed over the body. Each hair is situated in a tubelike sac called the *follicle*, made by the dipping down of the epidermis into the lower tissues. At the bottom of the follicle is a little knob, the *papilla*, made of capillaries and other tissue. It is from this papilla that a new hair grows as often as the old one is pulled out. The little teacuplike cavity in the end of the hair fits over the papilla, whereby nourishment from the blood readily reaches the hair (Fig. 117).

Baldness and Gray Hair. — The falling out of the hair does not, except in rare cases, result from bacteria, microbes, or any kind of germs, but is due to a lack of nourishment furnished by the papilla at its root. If the

papilla is dead, no substance will cause the hair to grow, and therefore no attention should be paid to the numerous advertisements offering for sale drugs or apparatus that will make hair develop on a bald head. The fact that Indians and others who never wear close-fitting hats do not become bald indicates that the pressure of the hat about the head, thereby shutting off to some extent the blood, may be one cause of baldness. Another cause may be the exclusion of fresh air from the head.

Dandruff commonly results from an unhealthy condition of the cells of the scalp. This may be remedied by washing the scalp thoroughly with tepid water and any good toilet soap weekly or bi-weekly. The soap should be well washed out with soft water, and the hair then dried as quickly as possible. The tendency to baldness is often hereditary, and frequently nothing will prevent it. In many cases, the hair, when beginning to fall out, may be invigorated by massaging, that is, pinching and wrinkling together various portions of the scalp a few minutes daily.

Fright, anxiety, or great care may turn the hair gray in a few weeks or even a single night, but usually the gray color appears gradually after the age of forty. It is due to air taking the place of the pigment in the central portion of the hair. There is no way of preventing the hair from becoming gray except by dyeing it frequently, a procedure which usually injures the hair and sometimes the general health.

The Complexion. — The great difference in the complexion of persons is due largely to the pigment lying in the lower part of the epidermis. In negroes there is much of the pigment, and it is very dark. In people of

light complexion only a little pigment is present. Tanning is the temporary development of extra pigment influenced by the rays of the sun.

The skin cannot be made soft, beautiful, and white by means of paints and powders. Some of them contain poisons, such as arsenic, and moreover they are likely to clog the openings of the glands, eventually giving an ugly complexion. Washing the skin with soft water and soap, eating fruits instead of sweetmeats, drinking much water or lemonade, taking plenty of exercise in the open air, and keeping the mind free of evil thoughts by thinking good ones are certain aids in producing a pleasing complexion and countenance.

FIG. 118. — Hand, showing the effects of chewing off the finger nails.

Hair growing on the face or in other regions where it is not wanted can be permanently removed only by means of the electric needle. Therefore, it is foolish to give heed to any of the numerous offers made by quacks in the newspapers to sell a drug that will permanently remove hair. The preparations so much advertised usually contain a compound of sulphur, which will dissolve the hair on the surface but will not kill the roots. If applied

several times, the skin becomes very sore and the hair tends to become thicker.

The Nails. — The nails are hardened epidermis. They protect the ends of the fingers if they are not cut too short. The very bad habit of chewing off the ends of the nails causes short and blunt fingers. The nails should be filed off every morning even with the finger tips, and the dirt should be removed from beneath the nails each time after washing the hands.

Fig. 119. — Hand, showing nails properly cared for.

Growths on the Skin. *Warts* are overgrowths of the epithelial cells. Their cause is not known. They are not harmful and may be easily removed by a physician, but are in no way affected by any words a fortune teller can say. *Moles* are slight elevations of the epidermis containing an increased growth of hair. They are usually inherited.

Cancer is probably not, as was once thought, the result of germs growing in the tissues, but is due to the cells of the body becoming deranged. They multiply rapidly and consume the other tissues, eating away blood vessels and nerves, so that in a year or two death often results. Cancer is not contagious. No one should pay any attention

to the numerous advertisements by doctors offering to cure cancer. Many tumors are called cancers and are easily cured, while some cancers cannot be cured by any means. Reliable physicians and surgeons never advertise cures. It is best to follow the advice of the family physician.

The Hot Bath. — Cold water will not cleanse the body thoroughly, and therefore every one should bathe the entire body at least once a week in hot water, using soap and friction to remove not only dirt but also the outer dead skin likely to clog the pores. Such bathing is an aid to health and a preventive of the unpleasant odors given off from an uncleanly body. The feet and certain other portions of the body should be washed daily to be kept odorless. The proper time for a hot bath is at night, as the heat draws the blood away from the brain, makes it less active, and tends to produce sleep. The bath should not be taken just after a meal, as the blood is drawn away from the digestive organs to the surface of the body.

The Cold Bath. — The hot bath may be taken as hot as one can bear it, but the cold bath should be from about sixty-eight to seventy-eight degrees. The most favorable time for a cold bath is immediately upon rising in the morning or just after exercising, when the body is warm. It should not last longer than one or two minutes, after which the body ought to be briskly rubbed with a rough towel. If a tub or regular shower bath cannot be had, almost equal results may be reached by standing in a wash bowl or small tub and pouring the cold water on the shoulders and letting it run down over all parts of the body.

Cold bathing is of great use in treating patients with nervous disorders or consumption, and in the healthy it tones up the system, and is a great preventive of colds if taken daily. Within a few minutes after leaving the cold bath, reaction should occur, when the capillaries and small arteries enlarge, the skin flushes, and there is a general sense of warmth and well-being.

Swimming and Bathing. — Swimming is one of the most helpful forms of exercise. It should, however, usually not be indulged in more than once a day, and then for a period not exceeding a half hour. When one is jumping about or swimming, the heat produced by the muscular exercise counteracts the effect of the cold water on the skin.

It is the duty of every one to learn to swim. The census report shows that during the years 1900 to 1904 about 40,000 people lost their lives by drowning. The ability to swim would doubtless have saved a large percentage of these. It is important to remember that there is danger in going into the water to swim when one is very tired, as the weary muscles are likely to go into cramps. The safest plan is never to go alone into water over one's head. Swimming just before, or sooner than two hours after, a heavy meal is unwise.

Clothing and Health. — The chief use of clothing is to aid the body in keeping a constant temperature and thus prevent sickness. Woolen clothing is warmer than cotton or linen clothing because it contains many meshes or tiny open spaces filled with air. This air prevents the escape of heat from the body. Therefore the clothing for cold weather should generally be of wool. Since woolen goods

do not absorb and pass off the sweat so quickly as cotton or linen cloth, the clothing worn next to the skin by vigorous and healthy persons should consist of loosely woven cotton or linen material for all seasons. As the clothing worn next to the skin absorbs the excretions coming from the sweat pores, it should be frequently washed. It is wise to change the underclothing weekly in winter and twice weekly in summer.

The body can be made comfortable while out-of-doors in cold weather, by wearing an overcoat or wrap. The feet should be protected from the wet by rain-proof shoes or overshoes. One should never sit in wet clothing but exercise until it can be exchanged for dry garments.

Alcohol and the Skin. — Repeated indulgence in the use of alcoholic drink makes the skin of the face puffy, and may give to it a blotched appearance, so characteristic of the confirmed drunkard. Alcohol enlarges the arteries and capillaries of the skin, and thus makes the face red, and in cold weather cools the body very rapidly, because so much of the warm blood is brought to the surface. In health seventy-five per cent of the heat leaving the body is lost by passing off from the capillaries of the skin. The use of alcohol may increase this loss of heat by ten per cent. The shivering fits on recovery from drunkenness, which frequently occur, are due to the fact that the body has lost a considerable amount of heat. The lowering of the temperature of the body by alcoholic drink may result in death. During a very cold night in winter several of a group of men, camping in the mountains in the West, drank considerable whisky before retiring, and as a result froze to death. Those who refrained from drink survived.

Questions

1. What are excretions? 2. Describe the kidneys. 3. How do the kidneys work? 4. Why should much water be drunk? 5. Explain the effect of alcohol on the kidneys. 6. Describe the epidermis. 7. Describe the cutis. 8. Of what use is the skin? 9. How does a corn differ from a blister? 10. Describe the sweat glands. 11. State five facts concerning perspiration. 12. Describe the oil glands. 13. What may cause baldness? 14. Give the cause and cure for common dandruff. 15. How may the complexion be improved? 16. Describe the care of the nails. 17. Why should one never employ a doctor advertising to cure cancer? 18. Of what use is a hot bath? 19. How often and when should a hot bath be taken? 20. Why should most people take a cold bath daily? 21. What care should be observed when swimming? 22. Explain the influence of alcohol on the skin.

Suggestions for the Teacher

The teacher should take this opportunity to impress upon the pupils the necessity of personal cleanliness, and the importance of caring properly for the nails and hair. Some of the pupils may be asked to give their personal experience in reference to the benefit derived from the hot and cold baths.

To show that wool is more serviceable than cotton in keeping the body warm, heat two small tin cans of water. Wrap around one a piece of cotton cloth and around the other a piece of woolen cloth weighing the same as the cotton cloth. Let the pupils note the difference in temperature by touching the water in each can at the end of a half hour or more.

To prove that wet clothing cools the body quickly, secure two pieces of cotton cloth of the same size and two jars of warm water. Wet one cloth and wrap it around one of the jars and put the other cloth dry about the other jar. At the end of a half hour test with the finger which jar of water is the cooler. The teacher may save some of the children from many colds and serious sickness by impressing upon them the danger of sitting still while the clothing is wet.

XVII. THE OSSEOUS SYSTEM, OR BONES

The Use of Bones. — The bones of the body are necessary for its support and also to enable it to move. The muscles, which are made to act by the nerves, pull upon some of the bones so as to move them in various ways. The bones protect the vital organs, such as the brain, spinal cord, lungs, and heart. All the red blood corpuscles, and many of the white ones, are made in the red bone marrow, occupying a portion of the interior of the bones.

The Parts of the Skeleton. — There are about 200 bones in the body. These joined together in their natural relations form the *skeleton*. It is divided into the *skull*, or bones of the *head*, *trunk*, and *extremities*, according to the table given on the next page.

The *cranium* is composed of the bones surrounding the brain, while the other bones of the head form the *face*. The *spinal column* is not a single bone, but is constructed of a chain of 24 bones, called *vertebræ*, in addition to the *sacrum* and *coccyx* formed of vertebræ grown together. Within a canal extending through the vertebræ lies the spinal cord. The same bones present in the human skeleton are also found in the dog or cat, and therefore the skeleton of these animals often discovered in the woods or fields may be used for study.

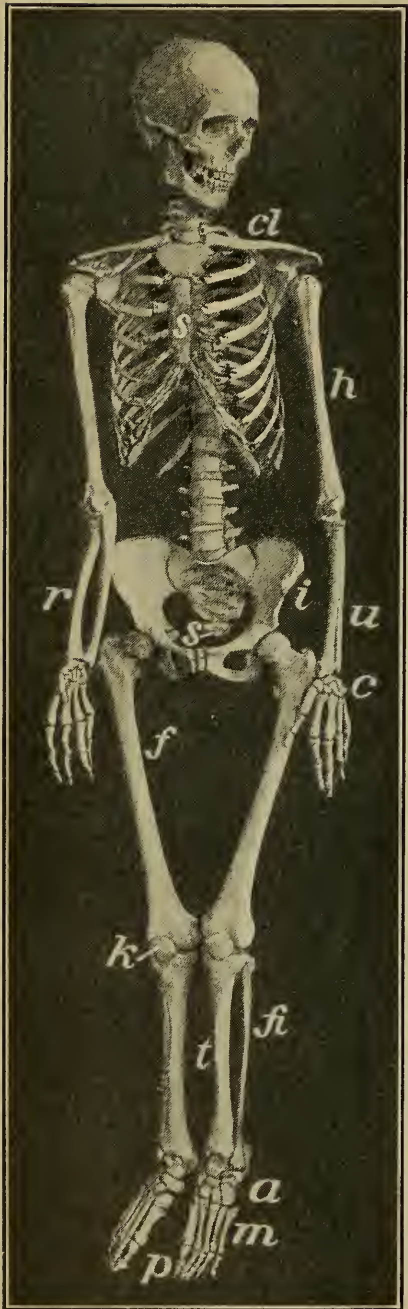


Fig. 120. — Human skeleton. See description in next column.

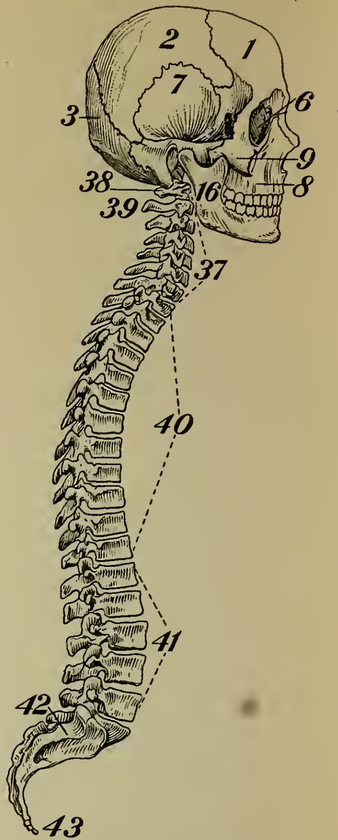


Fig. 121. — Side view of vertebral column and skull. See description below.

Figs. 120–121. — *a*, tarsals; *c*, metacarpals; *cl*, clavicle; *f*, femur; *fi*, fibula; *h*, humerus; *i*, innominate or hip bone; *k*, patella or kneecap; *m*, metatarsals; *p*, phalanges; *r*, radius; *s*, sacrum; *t*, tibia or shin bone; *u*, ulna.

1, frontal bone; *2*, parietal; *3*, occipital; *6*, orbital cavity; *7*, temporal bone; *8*, maxillary; *9*, malar; *16*, mandible; *37*, cervical or neck vertebræ; *40*, dorsal or thoracic vertebræ; *41*, lumbar vertebræ; *42*, sacrum; *43*, coccyx; *38* and *39*, spines of axis and atlas.

Table of Bones

The Skull or Bones of the Head	Cranium	frontal 1
		parietal 2
		temporal 2
		occipital 1
	Face	nasal 2
		inferior turbinated 2
		lachrymal 2
		maxilla or upper jaw 2
		mandible or lower jaw 1
		palate 2
		ethmoid 1
		sphenoid 1
		malar or cheek bone 2
		vomer 1
		hyoid 1
Bones of the Trunk	Spinal column or backbone	vertebra 24
		sacrum 1
		coccyx 1
	Other bones of the trunk	sternum or breast bone 1
		ribs 24
		innominate or hip bone 2
Bones of the Upper Extremity	Shoulder girdle	clavicle or collar bone 2
		scapula or shoulder blade 2
	Arm	humerus 2
	Forearm	radius 2
		ulna 2
	Wrist	carpal 16
	Hand	metacarpal 10
	Fingers	phalanges 28
Bones of the Lower Extremity	Leg	femur or thigh bone 2
		tibia or shin bone 2
		fibula 2
		patella or knee pan 2
	Ankle	tarsal 14
	Foot	metatarsal 10
	Toes	phalanges 28

Kinds of Bones.—In respect to shape, there are five groups of bones: the *flat bones*, such as those of the cranium, the shoulder blade, and the ribs; the *irregular bones*, including the ethmoid, sphenoid, and vertebræ; the *short*

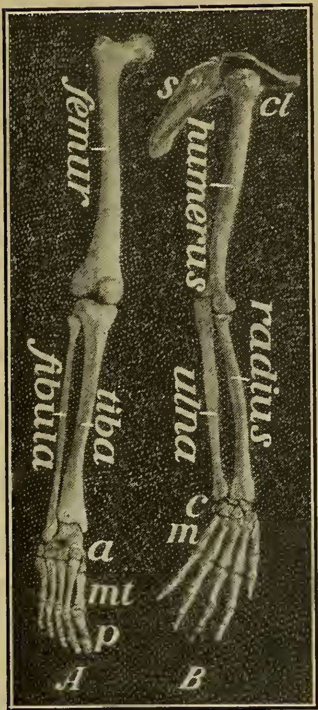


FIG. 122. — *A*, leg. *B*, arm. *a*, tarsus; *c*, carpus; *cl*, clavicle; *m*, metacarpus: *mt*, metatarsus; *p*, phalanges; *s*, scapula.

bones, represented by those in the wrist and ankle; the *long bones*, composed of a hollow *shaft* and two enlarged ends, such as those in the leg and arm; and the *sesamoid bones*, like the patella, formed in the region of joints by friction or pressure. The number of sesamoid bones increases in accordance with age and the amount of physical labor done.

Composition of Bone. — Bone is composed of *animal* and *mineral* matter, the latter of which is chiefly phosphate and carbonate of lime. By placing a slender bone from any animal in water containing one tenth part of nitric acid or hydrochloric acid, the mineral matter will be so completely dissolved out in four days that the bone will be as limber as cartilage. From another bone the animal matter may be removed by burning it a half hour in the stove, after which it will be so brittle as to crumble into dust at the touch of the fingers.

FIG. 123. — Rib from which the mineral matter has been dissolved by acid.

The Parts of a Bone. — All the bones are covered with a tough con-

nective-tissue membrane, named the *periosteum*. This serves for the attachment of tendons and muscles, and has the power of renewing any portion of bone removed by the surgeon on account of disease or accident.

FIG. 124. — Upper part of the femur cut open to show *c*, compact tissue; *cn*, cancellous tissue; *l*, medullary canal.

The bony tissue itself is of two kinds. One is called *compact* or *hard bone*, and the other is the *cancellous* or *spongy bone*. The outer part of the skeleton is made of compact bone, but it forms a very thin layer, except in the long bones, where it makes nearly all of the shaft, or middle part, between the enlarged extremities. The cancellous tissue is abundant in the interior of all bones, except the long ones, where it is chiefly present only at the ends. The shaft contains a cavity known as the *medullary canal*. This is occupied by the *medulla*, or white marrow. It is largely made of fat.

FIG. 125. — Thin slice of bone half the size of the cross section of a pin. The two white circles are Haversian canals, and the black spots are lacunæ or spaces for the living bone cells. Photographed through the microscope.

The Structure of Bone. — If a slice is sawed from a bone and ground very thin on a whetstone, it will present under the microscope many circular openings, called *Haversian canals*, which in life contained blood vessels and nerves. The numerous small holes in the surface of a bone are for the entrance of vessels and nerves to the Haversian canals. Irregular oval spaces, the *lacunæ*, with fine radiating channels are arranged in circles about the Haversian canals. Each lacuna in live bone is filled with a cell, which is nourished by the blood escaping from the vessels in the Haversian canals (Fig. 125).

Fig. 126. — X-ray view of the hand of a child five years of age. Only three of the eight bones of the wrist are formed and many of the end pieces of the other bones are not united to the shafts. Photographed by Dr. W. W. Seibert.

The Development of Bone. — Most of the bones, except those forming the top and sides of the skull, are developed from cartilage. This is a tough white substance, commonly called *gristle*. It may be easily bent and pressed out

of shape. In the young child, since much of the cartilage is not yet changed into bone, the legs may become bent or bowed if it is allowed to stand too much. In older children, during the first years of school, the thigh bones may be given a permanent curve backward if the seat is so high that the feet cannot touch the floor.

Fig. 127. — X-ray view of the hand of an adult. Photographed by Dr. W. W. Seibert.

The ends of most of the long bones are joined to the shaft by cartilage only until the sixteenth year, or even later. At birth the skull is quite incomplete on the sides and top, so that between the bones are six spaces where only membrane separates the brain from the skin. These are not completely closed by bone until near the end of the second year, so that a slight stroke on the head of a young child might prove very serious. Unless the clothing about the waist of children is worn loose, the bones of the thorax may be pressed in so as to prevent the internal organs from doing their work.

Broken Bones. — A break in a bone is called a *fracture.* As the bones of children bend easily, they are seldom broken off completely, but are cracked somewhat like a tough stick when bent. This is known as a *green-stick fracture.* When the bone of an older person is broken, the ends usually separate somewhat, owing to the pull of the muscles. In order to set the bone properly, the two ends must be brought together and held firmly in place by a thin board or sheet of metal bandaged on the limb. No one but a good physician is capable of setting a broken bone successfully. However, if a person with a fracture must be moved from the place of accident, it is wise to hold the broken bones in place by binding firmly on either side of the fracture, enveloped in clean cloth or cotton, a narrow board or flat stick. When the parts of the bone broken render little injury to the flesh, the fracture is said to be *simple.* A *compound fracture* is one in which the ends of the bone protrude through the skin. In young persons broken bones usually knit together in three or four weeks, but in persons over sixty years of age healing sometimes requires several months.

Fig. 128. — Femurs which were fractured. The one on the right was not properly cared for, and the ends have pushed over each other.

FIG. 129.— Temporary bandage for a broken bone until the surgeon arrives. *n* is a piece of board, and a similar piece is on the back of the arm.

Disease of Bones. — The commonest disease of bones is *tuberculosis*, caused by the growth of a minute plant, the consumption germ. *White swelling*, *hunchback*, *curvature* of the spine and hipjoint disease may result from bone tuberculosis. It is the most frequent in children fed on the raw milk of diseased cows or living in daily contact with a person suffering from consumption. It has lately been found that many cases can be cured by good food and fresh air, especially along the seashore. The first of the seashore sanatoria needed to treat the 60,000 children in this country suffering from bone tuberculosis was established in 1906.

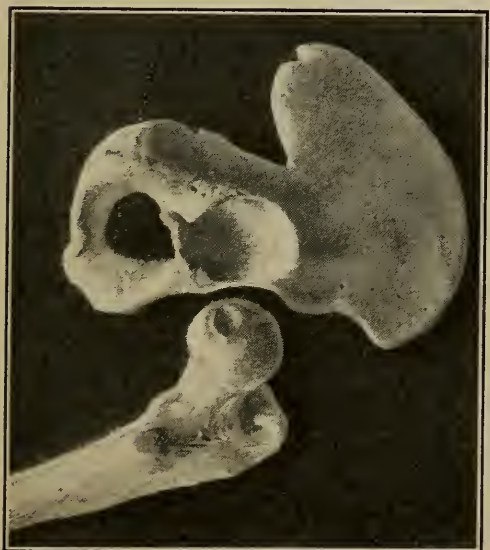


FIG. 130. — Hip bone and end of the thigh, to show the character of a joint.

A *felon* is an inflammation of the periosteum, caused by bacteria finding entrance and developing. *Rickets* occur in children not sufficiently nourished to permit the deposit

of enough mineral matter in the bones to render them hard.

The Joints. — The juncture of two or more bones is a *joint*, or *articulation*. The two general classes of joints are the *movable* and *immovable*. The immovable joints occur between the bones of the skull, and are often called *sutures*. The two important kinds of movable joints are the *ball and socket* joint, like that at the shoulder and hip, and the *hinge joint*, as seen at the knee and elbow.

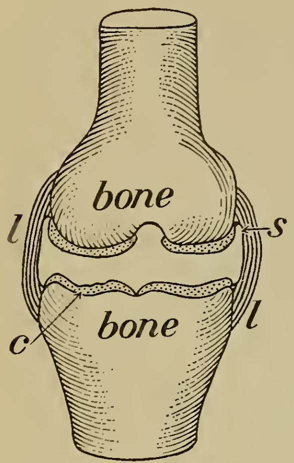


FIG. 131. — Diagram of a section through a joint. The bones are shown more separated and the cartilage thicker than in nature. *c*, cartilage; *l*, ligament; *s*, synovial membrane.

In the movable joints the adjacent ends of the bones are covered with a thin pad of cartilage, and several tough inelastic bands of white fibrous connective tissue, called *ligaments*, hold the bones in place, and form about the space between the ends of the bones a capsule. This is lined with a delicate membrane, called the *synovial membrane* (Fig. 131). It secretes from the blood a thick fluid, the *synovia*, similar to the white of egg. This glairy fluid is necessary to keep the joint moist.

Strain and Sprain. — By bending a joint too far or pushing the end of a bone to one side, the ligaments may be stretched and slightly torn, resulting in swelling and tenderness, called a *strain*. A severe strain is a *sprain*. The best immediate treatment is to immerse the injured part

in hot water or wrap it in cloths wrung out of hot water, and change them every few minutes. At the end of a half hour the joint should be massaged by rubbing it toward the body in order to move the collected lymph away to the veins. Unless the ligaments are torn, complete rest is not so helpful as careful exercise and frequent massaging.

Dislocation of Bones. — When at a joint the end of one of the bones is forced backward, forward, or to one side of the other bone so far that it does not slip back into place, it is said to be dislocated. The ligaments may be torn or greatly stretched. The services of a physician are usually necessary to remedy the difficulty. The bones at the knee and shoulder joints are the ones most frequently dislocated, and fortunately are often quite easily put in place by a strong pull on the limbs.

Narcotics and Bone Growth. — The bones derive material for their development from the food eaten. When the food has reached the stomach and intestine, it must be properly digested before it can be absorbed and carried through the body to build up the bones. Alcoholic drinks, soothing sirups for children, and tobacco have a tendency to diminish digestion. They, therefore, in some degree prevent the proper food supply from reaching the bones.

When the bone-building cells of the body are ever so slightly stupefied by narcotics of any kind, they fail to take from the blood and use what is needed to make sound bones. Evidence is gradually accumulating which indicates that the stunted frames of some children in alcoholic families are due in part at least to the effects of alcohol. On this account, beer should never be given to children.

Questions

1. Of what use are the bones? 2. What are the three parts of the skeleton? 3. Point out on your head the two parts of the skull. 4. Point out the location of five bones of the cranium. 5. Point out five bones of the face. 6. Of what is the vertebral column formed? 7. Give the number of ribs. 8. Name five bones in your upper extremity. 9. How many phalanges in each finger? 10. Wherein does the arrangement of the bones of the leg differ from that in the arm? 11. Give the composition of bone. 12. State five facts concerning the parts of a bone. 13. From what are bones developed? 14. Explain how broken bones should be cared for. 15. Why should a heavy strain not be put upon the bones of the young? 16. Point out on your body and name three kinds of joints. 17. Describe the parts of a joint. 18. How should a sprain be treated? 19. What is meant by the dislocation of a bone? 20. How does alcohol affect bone growth?

Suggestions for the Teacher

1. Ask a pupil to procure from a butcher a bone about a foot long, sawed lengthwise. Observe in class the periosteum, the red marrow, the white marrow, and the two kinds of bony tissue.

2. Secure from the butcher a joint. Look for the ligaments uniting the bones, by tearing away all muscle and fat. Cut open the joint and note the few drops of sticky synovial fluid and the transparent synovial membrane as thin as tissue paper on the inside of the ligaments.

3. Ask one pupil to show on another's arm how a fracture is to be treated when the patient must be moved before the arrival of the surgeon.

XVIII. THE MUSCULAR SYSTEM

The Parts. — The muscular system, like the other systems, is composed of parts or organs, each of which is a *muscle.* The muscle is the lean meat of the body and is made of a tissue which has the property of contracting or becoming shorter in length while its thickness increases. This change in shape is produced by a peculiar chemical action, resulting from a *stimulus* passing from the nervous system to the muscle. We can send this stimulus to most parts of the muscular system at will, and the muscles thus made to act are named *voluntary.* We cannot, however, control by our will the muscles helping to form the walls of the blood vessels, stomach, and intestines, and on this account they are known as *involuntary muscles.*

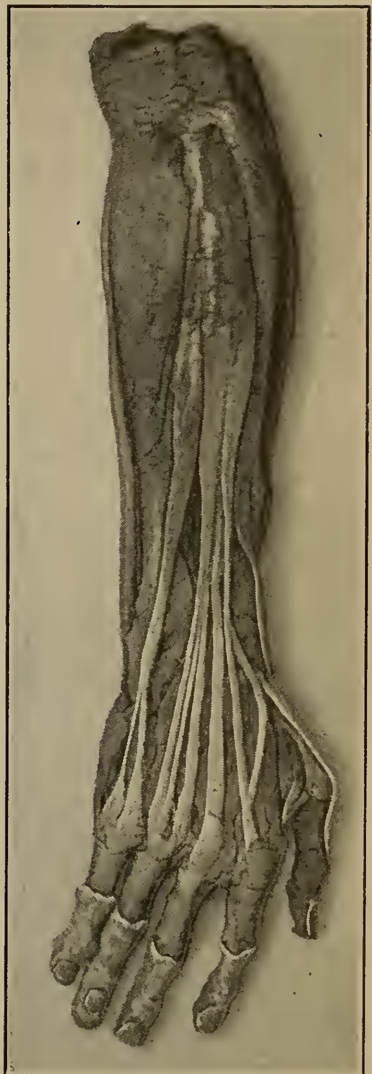


Fig. 132. — Muscles and tendons on the back of the arm.

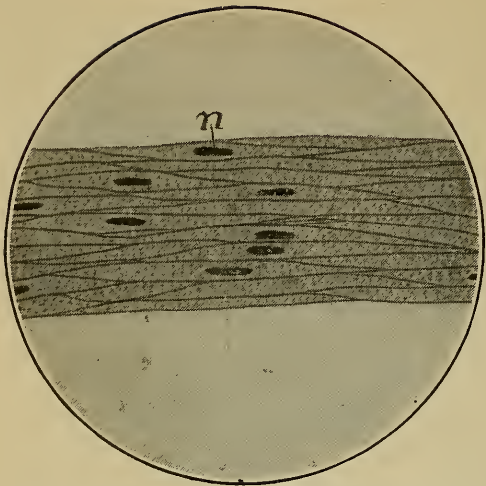


Fig. 133. — A tiny bit of involuntary muscle magnified to show the cells. *n*, nucleus.

The Involuntary Muscles. — They are often called *plain* or *unstriated muscles*, because of the smooth appearance of the cells seen under the microscope. The muscles in the skin and in nearly all of the tubes of the body are involuntary. The movements of the stomach and intestines and the contraction of the blood vessels helping to regulate the heat of the body are produced by the involuntary muscles. The will has no control over them, but when food comes into the intestines, it affects the endings of nerves there which are aroused to action, and the stimulus goes to the cells of the spinal cord, causing them to send out a stimulus to make the muscles of the intestines act. Cold, acting on the

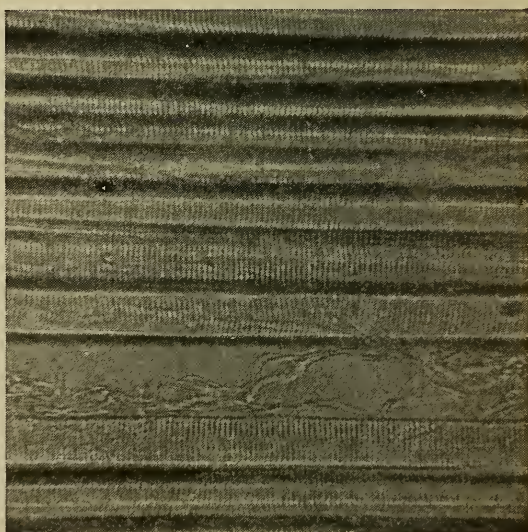


Fig. 134. — A bit of voluntary muscle as thick as a hair magnified to show the striations of fibers. Photographed through the microscope.

nerves, causes the muscles in the skin to contract and produce the rough goose flesh often seen on the bare arm after a cold bath.

The *heart* is made of involuntary muscle, but the cells, being short, thick, and striped, are quite different from those of the other involuntary muscles.

The Nature of a Voluntary Muscle. — What is usually spoken of as flesh or lean meat is composed of the voluntary or *striated muscles.* There are about 400 of them in the human body. They are of a reddish pink color, and each one is surrounded by a transparent sheath which is joined to the adjacent muscles.

Fig. 135. — Action of biceps muscle. *b*, extended; *a*, contracted; *h*, humerus; *s*, scapula.

The important elements of a muscle are the *fibers*, which have the shape of rods. They vary in length from less than a quarter of an inch to over two inches, and are so slender that a dozen of them together would not be as thick as a hair. The fibers are easily seen by tearing into bits, in a drop of water on a glass slide, a small piece of beef or other muscle, and examining it with the microscope. Between the fibers are numerous arteries, capillaries, and

veins for the purpose of supplying oxygen and food, and taking away the waste resulting from the life processes.

FIG. 136. — Flexor muscles on the front of the forearm with tendons at the wrist.

The Use of Muscles. — The chief function of the muscles is to produce motion in any part of the body. Usually the ends of a muscle are attached to different bones, so that when it contracts one of the bones must move. Several of the muscles attached to the bones of the fingers have their other ends fixed on the humerus (Fig. 136). The muscles pulling on the femur have an attachment on the hip bone. A muscle is able to contract nearly one fourth of its length.

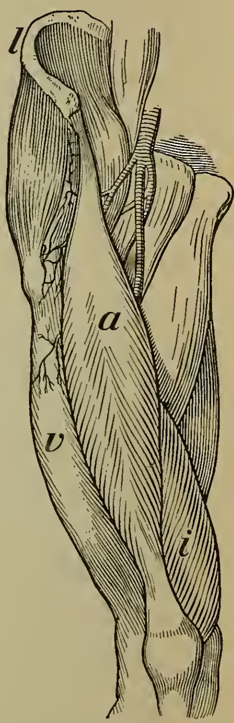


FIG. 137. — Muscles on the front of the thigh. *v*, *a*, and *i* are the three parts of the quadriceps extensor. *l*, hip bone.

The contracting muscles serve an important purpose in pressing upon the veins and lymphatics so as to move their contents, which must always go toward the heart on account of the valves in the vessels. Other uses for the muscles are to protect the blood vessels and nerves from injury and add beauty and symmetry to the form of the body.

The Arrangement of the Muscles. — In some regions of the body only a single layer of muscles covers the bones, while in other parts as many as three layers occur. Usually a muscle is attached to two different bones, but one end may be fastened to the skin or another muscle, and in some cases one end of the muscle is divided into several parts. The end of the muscle fixed on the bone which it moves is called the *insertion*, while the other end is the *origin*. The *masseter*, or chewing muscle, has its origin on the cheek bone and its insertion on the mandible.

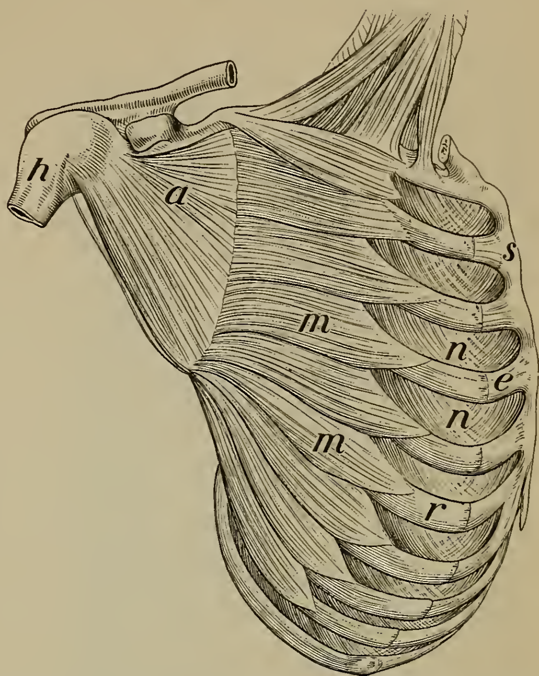


Fig. 138. — Some of the muscles used in breathing. *a*, muscles under the scapula; *e*, cartilage part of the rib; *h*, humerus; *m*, muscles pulling on the ribs when the arms are thrown backward; *n*, intercostal muscles; *r*, rib; *s*, sternum.

In some cases the muscle fibers join directly to the periosteum of the bone, but in others a tough white cord, called a *tendon*, apparently continuous with the muscle fibers, occurs at either or both ends of the muscle to connect it to the bone. The largest is the *Achilles' tendon*, which feels like a hard cord a half inch thick just above the heel. Several tendons may be felt in the wrist.

Kinds of Muscles. — In reference to the action effected, the muscles are divided into five groups: 1. the *flexors* are those which bend a limb; they occupy the palm side of the hand and arm, and the back of the leg (Fig. 136); 2. the *extensors* straighten a limb, and therefore lie on the side of the limbs opposite to the flexors (Fig. 132); 3. the *abductors* pull a limb or a part of a limb outwards, as when the arms are stretched outward on either side; 4. the *adductors* oppose the abductors, as seen in the action of the *pectoral* muscles of the chest when drawing the arm across the breast; 5. the *sphincters* are ring-like muscles and surround openings, such as the mouth and the eye.

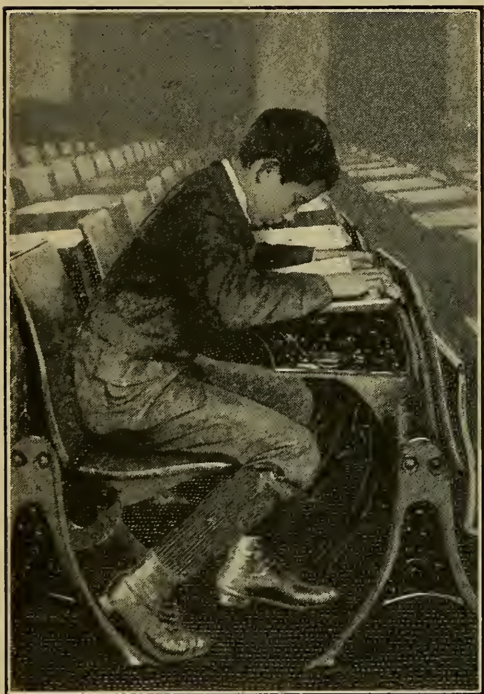


Fig. 139. — Portrait showing how the shoulders are rounded and the chest compressed, thus inviting tuberculosis.

The score of muscles controlling the eyes, mouth, and other features of the face are the muscles of expression, and on their action depends largely whether one has a pleasing or unattractive countenance. In one who is accustomed to pout, frown, or cry about every trifle, the muscles become so trained to pulling down the corners of the mouth, pushing out the lips and wrinkling the

forehead that the face can never have a pleasant aspect. Persons called homely are often the most delightful companions because of their pleasant looks and kind words, helping every one to wear a smile. A charming expression can be cultivated by any one.

Fig. 140. — Ungraceful attitude preventing the full expansion of the lungs.

The *diaphragm* and most of the other muscles attached to the ribs are concerned in respiration, because it is only when the diaphragm is pulled down or the ribs drawn up that the pressure is decreased in the chest so as to cause the air to flow into the lungs. The muscles of locomotion are those controlling the legs.

Exercise. — No one can remain in good health very long without taking some form of exercise. If one's regular work does not compel him to move nearly all of the muscles of the body, he must devise some plan that will bring the muscles into action. Neither a gymnasium nor expensive apparatus is necessary for the best form of exercise, though they are great aids in influencing the young in the right direction. The playing of some game in the open air, such as paper chase, and swimming, rowing, climbing trees, botanizing, and studying nature, are splendid ways of bringing all muscles into play. A tennis court well used will save doctor's bills.

Round shoulders, narrow chests, diseased lungs, sluggish liver, and constipation may be prevented or remedied

by exercise regularly taken. A good position in standing and sitting and a graceful carriage in walking should be practiced both for health and appearance. The drooping of the shoulders and the projecting of the chin and abdomen are common faults in young people. Exercise and fresh air have cured ten times more cases of consumption than all medicines combined. It is not overstudy that breaks one down and causes nervous prostration, but lack of exercise and fresh air. One of the most important parts of the treatment for the sick in sanatoria consists of certain forms of exercise.

Fig. 141. — A graceful and restful position conducive to health.

Massaging. — This process consists in pinching, pressing, squeezing, and kneading the muscles, skin, and internal organs in such a way as to cause the lymph with its collected impurities to pass away and the organs to become more active. A massage has somewhat the same effect as exercise. The circulation is stimulated, and the tissues purified. It likewise has a very beneficial effect on the nervous system. To massage most efficiently, one should have special training from an expert, but almost any one, with a little practice, can accomplish much in relieving pain and sleeplessness by rubbing and kneading the muscles so as to force the lymph and impure blood toward the heart.

Tobacco and the Muscles. — Nicotine causes the involuntary muscles of the small blood vessels to contract, and thus shut off some of the nourishment intended for the growth of the muscles. The habitual use of tobacco affects the growth of the young in a very marked degree. At Yale University during four years the non-users of tobacco gained 24 per cent more in height and 26.7 per cent more in the girth of the chest than the habitual users of tobacco. Dr. Seaver, of New Haven, found, on examining a large number of young men, that the tobacco users at 18 years of age were not so large and well developed as the non-users only 17 years old. That the use of tobacco dwarfs the young there is no doubt.

For perfect control of the muscles there must be a perfect nervous system. The nerve cells of the young are very delicate structures and cannot perform their duties accurately when dulled by such a poison as nicotine.

Professor Drawing, of the Naval Academy, says that smokers are not able to control their muscles accurately, and he can discover the tobacco users by their inability to draw a straight line or hold the hand perfectly still.

How Alcohol affects the Muscles. — Alcohol may stimulate the muscles for a few minutes somewhat in the same way that a whip urges forward a horse, but recent experiments all agree in showing that the daily amount of work accomplished by men using alcohol is always less than that done by the total abstainers. On this account no athlete while in training makes use of whisky, wine, or beer. Soldiers on forced marches are found to make better progress when denied the use of alcohol and given beef tea. Brigadier General A. W. Greely says that it should be

strongly urged that no alcoholic drink be used by soldiers undergoing great physical hardship and frequent exhausting labor.

Scientists, as a result of recent investigations, are unanimous in the opinion that a man can run faster, shoot straighter, and lift more without the use of alcohol than he can by using it in either small or large quantities. Sir Frederick Treves, in speaking of his experiences in the Boer War, says: "It is also curious that troops cannot work or march on alcohol. I was, as you know, with the relief column that moved on to Ladysmith, and, of course, it was an extremely trying time by reason of the hot weather. In that enormous column of 30,000, the first who dropped out were not the tall men, or the short men, or the big men, or the little men — they were the drinkers, and they dropped out as clearly as if they had been labeled with a big letter on their backs." The excessive use of beer tends to change the muscle cells of the heart into fat, so that the organ finally becomes weakened sufficiently to refuse to act, and sudden death results.

Questions

1. What special property is possessed by muscle? 2. Where are involuntary muscles found? 3. How are muscles made to act? 4. Give two features of involuntary muscles. 5. Explain the nature of voluntary muscle. 6. Of what use are muscles? 7. Explain the meaning of origin, insertion, and tendon. 8. Point out on your body and name four kinds of muscles. 9. Why does the expression of the face depend upon the muscles? 10. Explain how and why the muscles should be exercised. 11. Describe massaging and its effects. 12. How does tobacco affect the muscles? 13. Give facts showing that tobacco is injurious to muscular development. 14. How does alcohol affect the muscles? 15. How many muscles in the body?

Suggestions for the Teacher

1. The leg of a frog or chicken in which the muscles have been loosened from each other by cutting the connective tissue uniting them may be prepared by the teacher or some of the older pupils and kept permanently for demonstration. Ask the pupils to note the difference between the muscle and tendon, and how the muscle or tendon is joined to the bone.

2. Observe through the skin the three tendons on the front of the wrist, and by working the fingers and thumb determine where the tendons are inserted.

3. Require the class to perform some simple gymnastic exercises helpful in preventing round shoulders and flat chests. Call the attention of the pupils to the graceful positions in walking and standing.

4. When possible, it will prove of great interest and value to have a trained nurse or physician show the pupils how to massage and produce most helpful results in such simple ailments as a slightly sprained wrist or a stiff neck.

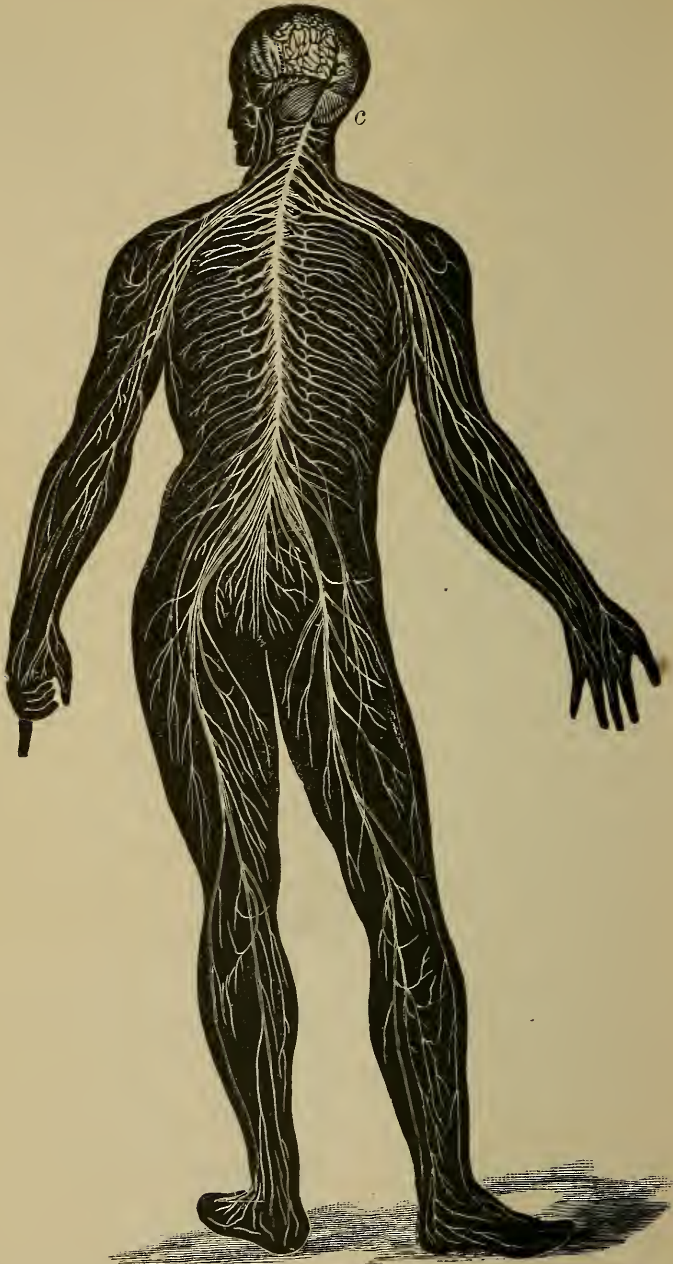


Fig. 142.—The nervous system. c, cerebellum; the large nerve of the leg is the sciatic; the white line down the back is the spinal cord.

XIX. HOW THE NERVOUS SYSTEM IS CONSTRUCTED

Parts. — The nervous apparatus of the body may be considered in three parts: the *central nervous system*, including the brain and spinal cord; the *nerves*, extending from the brain and cord to all parts of the body; and the *sympathetic system*, composed of bunches of cells, chiefly in the body cavity, with their nerves supplying the glands, and the involuntary muscle in the entire body. The nervous system bears the same relation to the organs of the body as the manager of a large establishment, with the telephone wires leading to all departments, does to the workmen. The brain and spinal cord direct the other organs as to the amount of work to be done, and the time to do it.

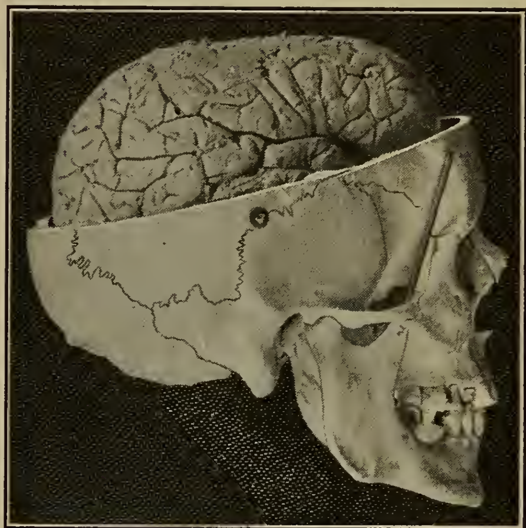


FIG. 143. — The brain in the skull, with its upper half removed. Membranes of the brain are taken off to show the convolutions appearing as folds separated by the sulci.

The Brain. — The brain fills loosely the cavity of the skull, in which it is securely fastened and protected by

three membranes, named the *dura mater*, *arachnoid*, and *pia mater*. The dura mater is tough and sticks closely to the skull, while the other two are very delicate. The pia mater, carrying blood vessels, dips down into all crevices of the brain. These crevices are known as *sulci*, and the larger ones, being an inch or more deep, are named *fissures*. The irregular convex portion of matter between any two sulci is a *convolution* (Fig. 144).

FIG. 144. — The brain from the side. *ce*, cerebellum; *c*, spinal cord; *m*, medulla oblongata; *p*, pons Varolii; *s*, fissure of Sylvius in the cerebrum.

The brain is in communication with all parts of the body by means of white cords, the *nerves*. Some of them branch in several places from the lower side of the brain, and extend to the head and neck, while others at the back part of the brain unite into a large bundle, called the *spinal cord*. This extends down the back within the inch-wide canal of the vertebræ, and gives off between the bones of the spinal column branches leading to the arms, trunk, and legs.

The Parts of the Brain. — The three parts of the brain most clearly marked off on the surface are the *medulla oblongata*, or *medulla*, the *cerebellum*, or little brain, and the *cerebrum*, or *forebrain*.

The *medulla* is the stem or bulb joining the higher parts of the brain with the spinal cord. With it are connected eight pairs of nerves distributed chiefly to the head.

The *cerebellum*, almost as large as one's fist, lies above and back of the medulla. Its surface is marked by deep cuts or sulci, forming plates of matter. The cerebellum is united to the other parts of the brain and the spinal cord by several bands of nerve fibers. The middle part of one of these is the *pons Varolii*, appearing as a flat band on the lower side of the brain just in front of the medulla.

The *cerebrum* is divided incompletely by the great *longitudinal fissure* into two equal parts, called *hemispheres*. They are connected with each other at the base and also with the other parts of the brain and cord by means of nerve fibers (Fig. 146).

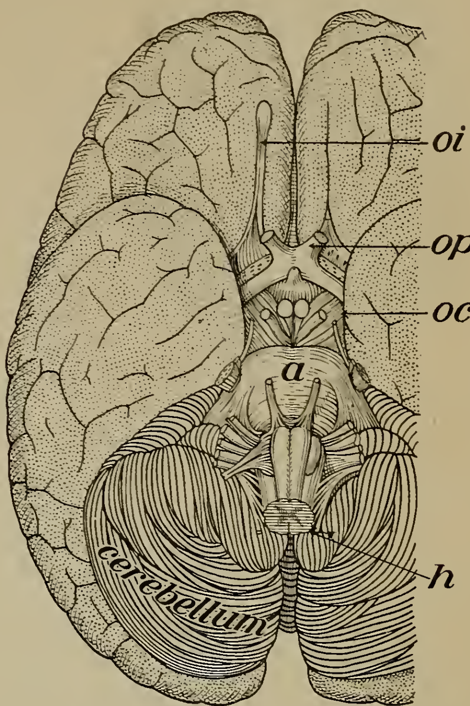


FIG. 145. — View of the brain from beneath, showing a dozen pairs of cranial nerves cut off. *oi*, olfactory tract, or roots of the nerve of smell, bearing at the end the bulb; *op*, the nerve of sight; *oc*, band of fibers connecting the cerebrum with the cerebellum and spinal cord; *a*, pons Varolii; *h*, medulla oblongata.

The Cerebrum. — Each hemisphere is divided into five indistinct parts, called *lobes*, and named according to the bones of the skull nearest them.

The two chief fissures, in addition to the great longitudinal one between the hemispheres, are the *fissure*

of Sylvius, above the ear, and the *fissure of Rolando*, extending from the crown obliquely forward and downward.

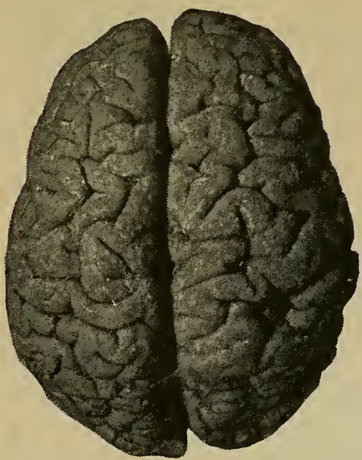


Fig. 146.—The brain from above, showing the two hemispheres separated by the great longitudinal fissure.

The General Structure of the Brain. — A section across the brain shows it to be composed of a thin outer layer of *gray matter*, called the *cortex*, and near the center other masses of gray matter, while the remainder appears white. Examination with the microscope shows that the gray matter is composed of very irregular, spherical, or oval cell bodies from which extend threadlike processes, called *fibers*, forming the *white matter*.

Fig. 147.—Cross section of the brain. *c*, band of fibers called corpus callosum. The thin membrane around the outside is the dura mater. Note the dark layer of gray matter or cortex on the surface.

Each cell body with all its processes is a true nerve cell, or *neuron*. There are usually several short processes, and frequently one long process, the *axon*, called by the older books axis cylinder process (Fig. 148). Some of the axones are more than two feet long and extend from the brain to near the end of the spinal cord. Axones are commonly called nerve fibers. Those which cross from one side of

the brain to the other and connect parts of the same name form bands, known as *commissures*, like the pons Varolii. The largest commissure is the *corpus callosum*, uniting the hemispheres of the cerebrum. Other fibers connect one lobe of the cerebrum with another.

The Spinal Cord. — The spinal cord is securely fastened in the upper three fourths of the canal of the backbone. It is about as thick as the little finger, and is surrounded by other membranes like those of the brain. It is round, except in the shoulder and lumbar region, where it is slightly flattened. In these two places it is also enlarged, owing to the great number of nerve fibers joining it from the arms and legs (Fig. 142).

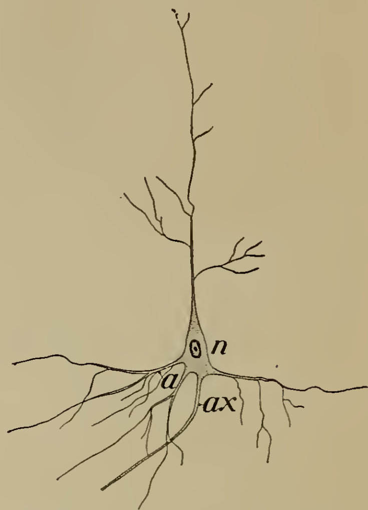


FIG. 148. — A complete nerve cell, or neuron. *ax*, long process cut off; *n*, nucleus.

A deep crevice, the *anterior fissure*, extending the entire length of the cord in front, and a similar incision, the *posterior fissure*, incompletely divide the cord into halves.

The Structure of the Spinal Cord. — A cord cut into crosswise shows two kinds of matter like that in the brain. The *white substance*, formed of fibers, is on the outside, while the central portion of the cord is *gray matter*, which in cross section appears H-shaped. This gray matter is made of the body of the nerve cells. These cells send many of their *axones*, or long processes, out to help form

the nerves supplying the arms, trunk, and legs. Some of the fibers forming the white matter of the cord convey messages toward the brain, while others carry messages in the opposite direction. On any fiber the message always travels in the same direction.

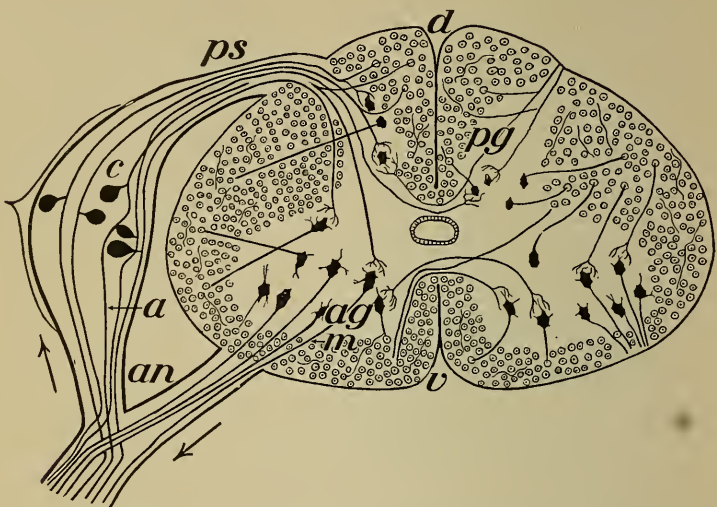


FIG. 149. — Cross section of the spinal cord, showing nerve roots on one side. *ag*, anterior horn of gray matter; *pg*, posterior horn of gray matter (nerve cells are black; the tiny circles are the ends of nerve fibers extending lengthwise of the cord); *ps*, sensory root; *an*, motor root (these two roots unite before coming out between the vertebræ); *c*, cell body whose fiber *a* extends to the finger; *m*, fiber extending to the finger (arrows show the direction of the impulse; only a few of the thousands of fibers actually present are shown); *v*, ventral fissure; *d*, dorsal fissure.

Kinds of Nerves. — The *cranial nerves*, of which there are twelve pairs, are those united to the base of the brain. The *spinal nerves*, numbering thirty-one pairs, join the spinal cord. Some of the nerves are for the purpose of transmitting orders from the central nervous system to the muscles, and are therefore called *motor nerves*. The *sensory nerves* carry messages from various parts of the

body to the spinal cord and brain. The nerve leading from the retina of the eye is a sensory nerve, while the nerve extending from the brain to the muscles to move the eye is a motor nerve. Frequently motor and sensory fibers are bound together in the same nerve, as is the case in all those nerves connected with the spinal cord.

Cranial Nerves. — All of the twelve pairs of cranial nerves, with the exception of one pair, supply the head, neck, or upper part of the shoulders. They are numbered from before backward according to the order in which they are joined to the brain. They are also named according to their function or in accordance with the region which they supply. The *first pair* of cranial nerves are the *olfactory*, or nerves of smell, and the *second*, or

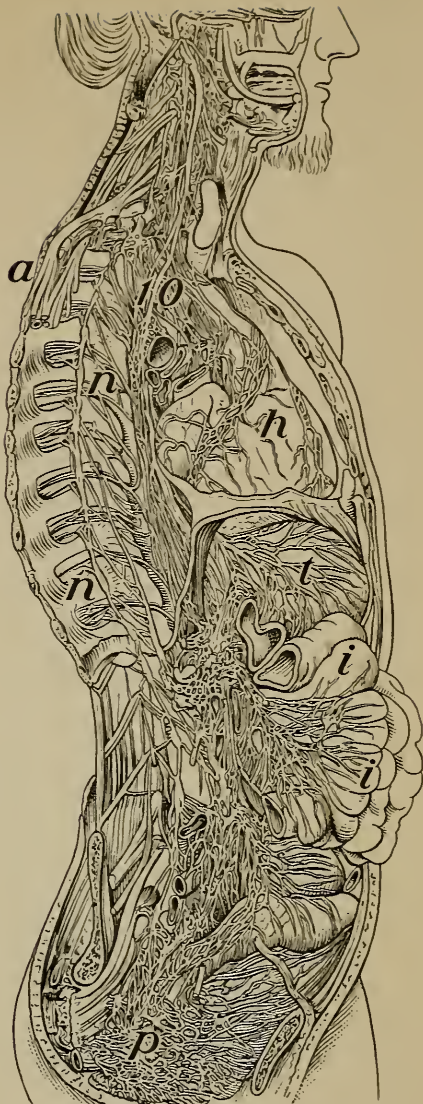


FIG. 150. — View from the side of part of the sympathetic nervous system within the body cavity. The white lines are nerves. *a*, spinal nerves to the arm; *h*, heart; *i*, intestines; *n*, ganglia, or bunches of cell bodies on the sympathetic nerve cord; *p*, one of the four large plexuses of the sympathetic system; *t*, stomach; *10*, tenth cranial nerve to lungs and stomach.

optic, are the nerves of sight. The *eighth pair* are the *auditory nerves*, leading from the ear.

Spinal Nerves. — All the 31 pairs of spinal nerves contain both motor and sensory fibers. Each nerve is united to the cord by two branches, named *roots*, the back one of which is the *dorsal root*, and the front one is the *ventral root*. If the dorsal root of a spinal nerve is cut, the part of the body supplied by the nerve is without feeling, while if the other root is cut the muscles it supplied cannot be moved (Fig. 149).

The Nerves to the Limbs. — About 200,000 fibers are present in the nerves in the upper part of the arm. The two largest nerves are the *median* and the *musculo-spiral*. A continuation of one division of the median nerve along the radius is the *radial* nerve, and the other division along the ulna is the *ulnar* nerve.

Usually the larger nerves, veins, and arteries lie together, and are not near the surface. The ulnar nerve, however, is so near the surface at the inner side of the elbow that it is often struck. It is then usually said that the funny bone has been hit, because of the queer feeling in the ends of the fingers to which the nerve extends. Several spinal nerves in the lumbar region are united by fibers to form a network or *plexus*, from which branches are distributed to the legs. The largest nerve of the leg is the *sciatic*.

The Sympathetic Nervous System. — The sympathetic nerves connect all internal organs with the central nervous system and supply the glands and involuntary muscles of the entire body. This system consists of three parts: 1. a nerve cord uniting 23 ovoid ganglia, lying on

either side and somewhat in front of the spinal column; 2. numerous fibers extending from these two main cords and ganglia to the viscera, on which they form networks, called plexuses; 3. many fine fibers which accompany the spinal and cranial nerves to supply the glands and involuntary muscles throughout the body (Fig. 150).

This system is connected with the main nervous system by numerous branches. The will has no direct control over the sympathetic nerves, which, against one's wish, may refuse to make the gastric juice run or may relax the muscles of the arteries and produce blushing.

Questions

1. Give the three parts of the nervous system. 2. What is the relation of the brain and spinal cord to the rest of the body? 3. Explain the terms sulci, fissures, and convolutions. 4. What connects the brain with other parts of the body? 5. Give the parts of the brain. 6. Describe the cerebellum. 7. Give four features of the cerebrum. 8. What part of a neuron composes the gray matter of the brain? 9. Explain axon. 10. What is a commissure? 11. Give the size and location of the spinal cord. 12. Of what use are the nerve fibers? 13. Why are some nerves called cranial and others spinal? 14. How does a motor nerve differ from a sensory? 15. Name the cranial nerves of sight, smell, and hearing. 16. To what parts do most of the cranial nerves extend? 17. Explain how a spinal nerve is attached to the cord. 18. State five facts concerning the nerves to the limbs. 19. Over what nerves does the will have no control? 20. To what organs do the nerves of the sympathetic system extend?

Suggestions for the Teacher

1. The brain of a calf or sheep may be secured from the butcher. Request him to break it as little as possible in removing it from the skull and to leave the membranes on. Note the tough dura mater which should be cut loose with the scissors. The two other membranes are so thin that the brain may be seen through them. Note that the

convolutions are much fewer than in the human brain, and that the cerebrum does not cover the cerebellum. Observe the depth of the fissures and the white and gray matter, seen by cutting through the brain. On the under side look for the two bands of fibers diverging in front of the pons Varolii, the one going to the right and the other to the left hemisphere. Through these, impulses travel to and from all parts of the body. The brain may be hardened so that it can be sliced, by dropping it into the formaldehyde solution for a week.

2. A piece of the spinal cord of a sheep or pig may be had for the asking at the butcher shop. The arrangement of the white and gray matter is easily seen, and if care is used in removing the cord, the nerve roots may also be seen. The nerves may be studied in the hind leg of a frog or of a chicken, where they appear as white glistening cords as thick as a pin or thicker.

3. The interest of the pupils may be greatly increased and lasting impressions may be made by showing with a microscope a thin slice of the brain or spinal cord. If the school has no microscope, a physician may usually be found in every locality who will take pleasure in showing the children the wonderful cells upon which every thought and movement depend.

XX. HOW THE NERVOUS SYSTEM WORKS

The Use of Nerve Cells. — It is by means of the nervous system that all parts of the body are made to work harmoniously. The muscles are directed when to act, and the stomach makes known its needs by messages sent through the nerve fibers to the cord and brain. How the message travels no one knows, but it goes very quickly. The time required to send a message from a man's toe to the brain and back again is about one third of a second. The processes of the nerve cells serve the same purpose as the telegraph wires of a railway, but the bodies of the nerve cells are of two kinds. Those in the spinal cord and medulla are like the telegraph operator, and can send only such messages as are given them. The cell bodies in the cortex of the brain are like the manager of the railway, and can form the message in themselves, and then direct the nerve cells in the lower parts of the brain and in the cord to send it to a part of the body. How these cells in the cortex of the brain are related to the mind is not known.

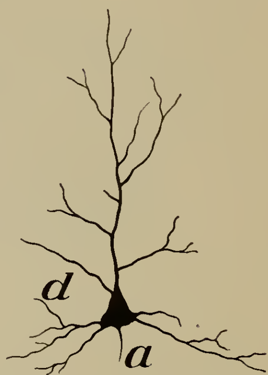


FIG. 151. — Nerve cell from the cortex of the brain. *a*, axon, which may extend to the end of the spinal cord. Magnified.

How the Brain Acts. — Each part of the brain has its own work to do. The *medulla oblongata* is the only portion of the brain whose destruction causes immediate death. A knife may be run through the cerebrum and all of the cerebellum cut away without fatal results. The cells in the medulla control the breathing and the heart beat, and also have much to do with the motion and secretions of the alimentary canal.

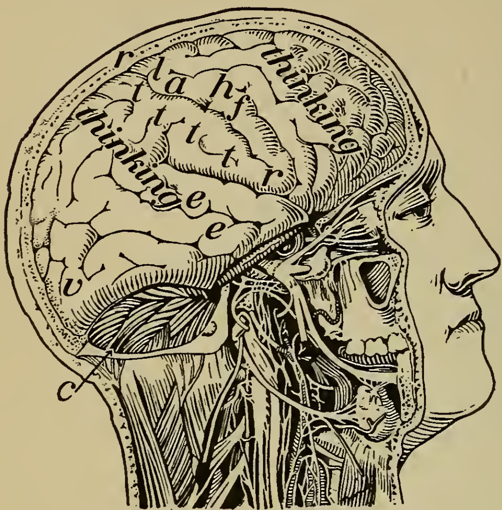


FIG. 152. — Skull cut away to show parts of the brain used for various purposes. *c*, cerebellum; *rr*, fissure of Rolando; *l*, cells moving the leg; *a*, cells moving the arm; *h*, cells moving the hand; *f*, cells moving the muscles of the face; *t*, cells receiving the impression of touch; *v*, cells used in seeing; *e*, cells used in hearing.

The *use of the cerebellum* is not well understood. Animals in which it is injured can move the muscles, but they are unable to contract at the same time and in the right degree the score or more of muscles necessary for any act, such as walking. As a result they tumble about like a drunken man. This inability to make the muscles act in harmony is lack of *coördination* of muscular movements.

The Use of the Cerebrum. — The cerebrum is the seat of the mind. All processes of thought depend upon the nerve cells in this portion of the brain. That part of the cortex along the front of the fissure of Rolando is called

the *motor area*, because the cell bodies here are able to produce motion in all voluntary muscles of the body (Fig. 152). A slight knock on top of the head causes one to fall down, because the cells of the motor area are stunned. Most of the long processes of these cells extending down through the brain cross over to the opposite side in the medulla to form part of the white matter of the spinal cord. Therefore an injury to the left hemisphere affects the muscles on the right side of the body.

The *sensory area* is along the posterior side of the fissure of Rolando. The cells of this region receive the impulse aroused in the skin by pressure, heat, and cold. Destruction of all the sensory area makes one insensible to heat, cold, and touch. The *area for sight* is in the cortex of the back part of the cerebrum. If this is destroyed one cannot distinguish by sight a ball from a top or a butterfly from a wasp, because the cells which told the mind the visible characters of those things are gone.

The *area for hearing* is in the temporal lobe, and near by are the cells concerned in smelling and tasting.

What the Spinal Cord Does.—The cord serves two purposes. It is a path of communication between the nerves supplying the arms, trunk, and legs, and the brain. An impulse to kick starts from the brain's motor area, formed by cell bodies, and passes along their processes down the spinal cord to the lumbar region. Here another set of cell bodies receives the message, and through their processes forming part of the sciatic nerve carries it to the muscles of the leg.

The second function of the cord is to act independently

of the brain and produce many of the muscular movements necessary in routine work. This is spoken of as *reflex action* (Fig. 153).

Reflex Action. — This is any action of the nervous system without the use of the will. Tickling the foot of the soundest sleeper causes it to be moved, but the brain is asleep and the will did not act. The cells in the cord aroused by the tickling sent a message to make the muscles move. The squirming of a snake with a mashed head, the jumping of a chicken with its head cut off, and the wriggling of the pieces of a freshly cleaned eel placed in the hot frying pan are *reflex acts* in which the brain can have no part.

Reflex action causes the hand stuck with a pin to be withdrawn before the brain can act. The stimulus travels up the nerve fibers of the arm and through the sensory cells of the dorsal root, then out their processes to pass over to the motor cells in the spinal cord. These cells are thus aroused to send the message to the muscles to contract. A twentieth of a second later the brain is aware of the pin, because the sensory fibers, upon entering the cord, split and send branches also up toward the brain (Fig. 153).

The Use of the Sympathetic System. — The working of this system consists of a series of reflex actions. These nerves control the involuntary muscle in all parts of the body. They help govern the movements of the intestines and the heart beat, and determine the amount of blood supplied to various parts of the body by contracting or loosening the muscle in the walls of the small arteries. This system regulates the activity of the sweat glands

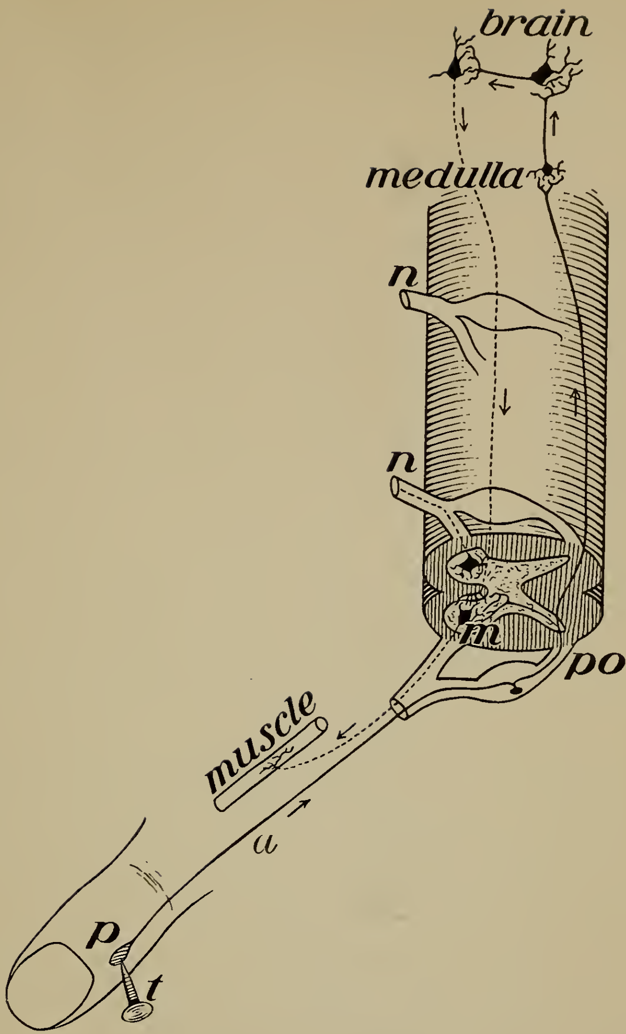


Fig. 153. — Diagram of reflex action. — Arrows show which way the impulse is traveling; n, spinal nerves. When the finger is pricked by a tack t, the nerve ending p receives the pain impulse and it is carried along the fiber a through the sensory root around into the spinal cord. Here the impulse is given to the cell m, and its fiber then conveys the impulse down the arm to the muscle causing the finger to be withdrawn. The sensory fiber passing in at po splits inside of the cord, and one branch takes the message to the brain. Here it passes to the motor cells, which may order the finger held still or withdrawn.

and influences the secretion of the salivary glands, and causes the flow of tears.

Paralysis and Apoplexy. — Paralysis is inability of the nerves to act because of injury to the cell bodies or the processes. The breaking of a blood vessel in the brain or cord, so as to produce a clot to press on the cells or fibers, will cause paralysis in those parts of the body to which the fibers help convey impulses. The growth of a tumor in the brain or the pressing of a bone on nerves may also result in paralysis. *Apoplexy* is quick paralysis, usually brought on by the bursting or clogging of a blood vessel in the brain.

How the Uses of the Brain have been Determined. — Since the dog, rabbit, pigeon, frog, and all other animals with a backbone possess the five parts of the brain arranged in the same order as in man, much information about the use of the brain has been secured by experimenting on the lower animals. In these creatures, put to sleep by drugs, the effects of stimulating the nerves have been noted, and the influence of all parts of the nervous system on the various organs learned. Other knowledge has been derived from studying those sick with nervous ailments, and then, after death, cutting open the bodies to see exactly where the cause of the trouble was. Much of the physiology of all organs has been learned from the study of the lower animals. Experiments on them have given the doctors information enabling them to save thousands of human lives and a vast amount of suffering.

Brain Weight and Intellect. — The brain is smaller in women than in men because the body is smaller. The average weight of the male brain is three pounds and two

ounces, while that of the female is two pounds and twelve ounces. In mental workers the brain grows until the age of 40 years, and after the age of 50 it loses about one ounce during every 10 years. The brain of those doing the same work from day to day, such as shoveling coal or working in a factory, so that the mind is not kept active, ceases to grow after the twentieth year of age.

A *good mind* does not depend so much upon the size of the brain as upon the development of the processes of the nerve cells. In a general way, however, the size of the cerebrum and especially the number of the convolutions and the depth of the sulci indicate the degree of intelligence in animals. A man's brain is larger than that of any other creature, except the elephant and the whale. A whale weighing 12,000 pounds has a brain only 10 ounces heavier than the brain of a man weighing 120 pounds.

Why the Brain needs Exercise. — A muscle grows by use, and the same is true of the brain. In the young there are many nerve cells with short processes or none at all. The processes may be made to develop by exercising the cells, as when one studies. Thinking causes the blood to flow to the brain, and so brings more nourishment for the cells. To express a thought in one's own language is worth ten times more for mind growth than to state it in words learned from the book.

Observing the features of a bird and then striving to identify it from the description in the book, or noting the characters of a cow so as to tell her value compared with other cows, develops important brain cells and is worth vastly more than memorizing a half-dozen pages in a

book. Professor Donaldson, who examined the brain of Laura Bridgman deprived early of sight and hearing, says that the nerve cells in the sight and hearing areas of the brain were much smaller than those in other persons. Like the other tissues, the brain, upon which the mind depends, grows faster in youth, and no amount of exercise will make it develop late in life. On this account one should hold steadfastly to school while young.

Habits. — The doing of one thing over and over again calls into action the same set of nerve cells, and they finally become so accustomed to act that they do so without the aid of the will and often even against it. This is habit. A boy long accustomed to swearing, acting rudely, eating rapidly, or looking sullen cannot refrain from these ungentlemanly habits later in life, even when honestly trying to do so. The cultivation of agreeable manners and pleasant looks not only makes friends in school, but makes success in later life. Evil thoughts passing often through the cells leave a blot there which can never be entirely erased. The first step toward wrong doing is in wrong thinking. Many cases are known where the reading of books and newspapers describing wicked acts has affected the nerve cells so as to cause the reader to commit robbery and other crimes.

The youth who causes to pass through his nervous system into the mind noble thoughts from good people and good books, and who learns industry, patience, and politeness, is sure of friends and success in life. The mind is like a piece of ground which, if not sowed with good seed and cultivated, will grow up with worthless weeds. It is therefore important that one should keep

the mind busy in doing what will yield the right kind of harvest.

Sleep. — It is just as important to rest as to work. The only time when the nervous system rests completely is during sleep. Adults, as a rule, should sleep eight hours every night, while those younger should add fifteen minutes for every year under the age of twenty. Loss of sleep is sure to result in ill health sooner or later. The time for retiring should be the same every night, so that one will drop off to sleep within five minutes after lying down. Without the advice of a physician medicine should never be taken to produce sleep. Placing the feet in hot water a few minutes, taking a hot bath, or a half glass of hot milk is an aid to sleep.

The Nervous System and Tobacco. — Tobacco habitually used by the young has a more serious effect on the nervous system than on any other part of the body. It prevents the brain cells from developing to their full extent and results in a slow and dull mind. Chief Justice Brewer, of the United States Supreme Court, says: "No cigarette smoker can attain the highest position in the world." At Harvard University during fifty years no habitual user of tobacco ever graduated at the head of his class. The New York Division of the Reading Railroad, which prohibits cigarette smoking by employees, says: "Men who smoke cigarettes are liable to lapses of memory, and it is not safe to trust the lives of passengers in the hands of men who have that failing."

Recent careful investigations by many persons show that cigarette smoking not only clouds the intellect, but tends to make criminals of boys. Dr. Hutchison, of

the Kansas State Reformatory, says: "Using cigarettes is the cause of the downfall of more of the inmates of this institution than all other vicious habits combined." Of 4117 boys received into the Illinois State Reformatory, 4000 were in the habit of using tobacco, and over 3000 were cigarette smokers.

It is unwise to begin the use of tobacco, because when the habit is once acquired it can be broken only by one with a strong mind who is willing to endure suffering caused by the longing nerve cells during the first few weeks after being deprived of their accustomed poison.

How Alcohol affects the Nervous System. — Much of the alcohol consumed is absorbed by the blood vessels of the stomach, so that it reaches the nerve cells in a few minutes. A large amount of alcohol paralyzes them, as may be judged by the actions of a reeling drunken man. In many persons a half teacupful of strong wine will affect the brain perceptibly.

A drink of whisky or wine may help one to talk more, because it removes the careful judgment which one should give a thought before he utters it. On this account persons, after drinking, often reveal secrets and say very silly things. All late investigators declare that a student can perform more mental work in a day without alcohol than he can by the aid of either small or large quantities of any alcoholic drink. The excessive use of alcoholic drinks, whether pure or impure, may cause *delirium tremens*. This is a severe poisoning of the nerve cells, resulting in trembling, weakness, and great fear. Often the victim thinks he sees horned animals, spitting insects, and snakes.

The continued use of liquor in many cases produces a gradual change in the nerve cells so as to affect the mind and cause a tendency to crime. This fact is very clearly shown by the careful investigations of the Committee of Fifty, who inquired into the history of 13,402 convicts, and ascertained that intemperance was a strong factor in the downfall of over 6000 of them. Alcohol was the first cause of crime in over 4000 of these convicts. The government report of Massachusetts states that one sixth of all of the crime in that state is due solely to alcohol. Russia reports that one fourth of her crime results from alcohol. Intemperance causes a little over one half of the crime in England.

The mind cannot be strong and sound when the brain cells are being constantly injured by large daily doses of beer, wine, or whisky. Numbing the cells of the brain or affecting them in any way by alcoholic drink always has some influence on the mind. The reports of the Commissioners of various insane asylums show that nearly one fourth of the male persons confined in them owe their insanity to alcohol. The report of the Waterford Lunatic Asylum in Ireland for 1903 states that the most frequent cause of insanity of those admitted was intemperance.

The poisonous effects of alcohol on the nervous system of the parent are in many cases transmitted to the children. Havelock Ellis says that some of the most characteristic cases of criminality in children are solely or chiefly due to the use of strong drink by the parents. Dr. Keer reports that in one family after the birth of a healthy son and later a healthy daughter, the father

became a drunkard. Of the four children born after this, three were idiots.

Professor Hodge, of Clark University, tells of 10 alcoholic families in which there were 57 children, and only ten of them were healthy. Some were idiots and some were epileptics. There are about 200,000 idiots and epileptics in the United States, and it is probable that some of them owe their condition to the drunkenness of their parents. During the next ten years after the spirit tax was removed in Norway, drunkenness increased markedly and the proportion of idiots born increased 150 per cent. Scientific investigations confirm the warning of the Scripture: "The sins of the parents shall be visited upon the children even unto the third and fourth generation."

Questions

1. How do the nerve fibers differ in function from the cell bodies? 2. Explain the use of the medulla. 3. What work does the cerebellum perform? 4. Upon what part of the brain does thought largely depend? 5. What is meant by motor area? 6. Explain the sensory area. 7. What are the two uses of the spinal cord? 8. Explain reflex action. 9. What causes paralysis? 10. How have the uses of the different parts of the brain been learned? 11. Give some facts concerning the weight of the brain. 12. What elements in the brain determine the making of a good mind? 13. How can one increase the amount of nourishment carried to the brain? 14. Why should you not memorize the words of your lesson? 15. Why is it important to exercise the brain in youth? 16. What habits are dangerous and why? 17. State five facts about sleep. 18. What effect has alcohol on the nervous system? 19. Explain the cause of delirium tremens.

Suggestions for the Teacher

Ask some of the pupils to tell how they have been able to stop some bad habits, such as chewing the finger nails, speaking in a loud and rude manner, or frowning.

XXI. THE SENSE ORGANS

The Nature of the Sense Organs. — The sense organs are the terminations of the sensory nerves serving to carry impressions to the spinal cord or brain. They are the means by which all messages of information get on to the nerves to be carried to the central nervous system. One's knowledge of an apple is secured through certain sense organs in the skin touching the apple, through the sense organs in the nose affected by the odor of the apple, through the sense organs in the tongue aroused by its sweetness, and through the sense organs of sight stimulated by the light reflected from the apple. None of these impulses excited in the sense organs can give rise to sensations until they reach the brain. A man had his back broken so that the bones pressed on the cord, preventing its nerves from carrying any message up to the brain. When his feet were tickled, the legs would jump about, showing that the sense organs of the skin had sent the stimulus up the nerves to the cord, exciting an impulse in the motor cells there, but the man said he felt no touch on the feet. No sensation of tickling was produced, because the impulse received by the organs of sense could not reach the brain.

The Kinds of Senses. — Two general classes of senses are known. The *interior* or *general senses* are those telling a person of the condition of the body. To this class

belong the senses of hunger, pain, thirst, and fatigue. The *exterior senses* are the *special senses*, such as those of *temperature*, *pressure*, *smell*, *taste*, *hearing*, and *sight*. The senses of temperature, pressure, and pain, which the older books call the sense of touch, are now known to be just as different from each other as sight and hearing.

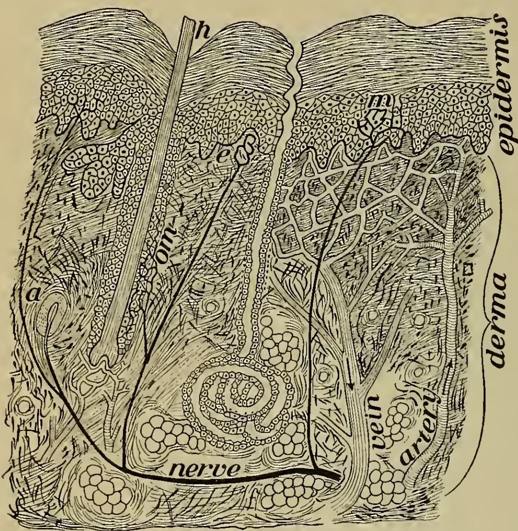


FIG. 154. — Section of the skin showing various kinds of nerve endings at *om*, *m*, *e*, and *a*; *h*, hair.

The Senses of the Skin. — These are often called *cutaneous senses* and include *temperature*, *pressure*, and *pain*. There are certain nerves with their special endings scattered throughout the skin to receive the stimulus of cold, and an entirely different set of nerves and sense organs to receive the knowledge of heat. The sharp point of an icicle can be placed on certain very small spots of the skin without any cold being felt, because the sense organs for cold are in many places a quarter of an inch or more apart.

The sense organs for *pressure* are the nerve endings around the roots of hairs, and where these are absent minute oval bulbs, called *tactile corpuscles*, occur. A hair cannot be disturbed ever so gently without a sensation of touch or delicate pressure. The lining of the alimen-

tary canal below the mouth does not possess any sense organs of temperature or pressure, and therefore the movement of the food is not felt except when sickness makes the end organs of pain more sensitive.

The *sense of pain* has separate nerves with their organs of sense widely distributed throughout the body. This sense is of great service in telling an individual when any of the organs are sick or are being injured. Freezing or an application of cocaine numbs the sense organs of pain and is often used in operations by the surgeon.

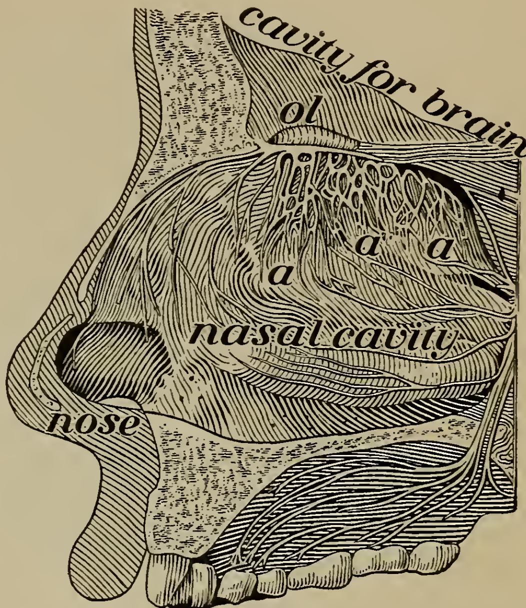


FIG. 155. — Section through the nose. *a*, distribution of the nerve of smell connected with *ol*, the olfactory lobe lying beneath the fore part of the brain.

The Sense of Smell. — The sense organs of smell are located in the mucous membrane lining the upper part of the cavity of the nose. They consist of hundreds of long columnar cells, each of which bears on its outer end from six to eight hairlike processes. Particles of matter in the form of gas, striking these processes, send a stimulus by the olfactory nerves to the brain, producing the sensation of smell.

A cold excites a secretion of mucus in the nose so as partly to cover the organs of smell, and also results in an

inflammation of the membrane bearing them, so that they are not able to act. During a cold many foods seem to have little taste, because it is the odor rather than the taste that gives the desired quality to some eatables. The pleasure from eating onions, coffee, and cheese will be greatly lessened if one holds his nostrils shut.

FIG. 156. — Section through one side of a large papilla on the tongue, showing five taste buds and the nerve of taste, n.

The Sense of Taste. — The end organs for taste occur in the mucous membrane of the tongue, soft palate, and other regions of the throat. They are minute oval bodies, called *taste buds*, each of which is connected with a nerve fiber extending to the brain. The taste buds are most abundant in the dozen or less *circumvallate papillæ*, at the back of the tongue, and in the *fungiform papillæ*, appearing as white dots all over the top of the tongue (Fig. 91).

A substance can arouse the sense of taste only when in the form of a liquid or dissolved in a liquid. It is important that all food should be chewed many times and dissolved as completely as possible in the mouth so as to affect the taste buds. This causes the gastric juice to

flow abundantly. Careful experiments teach that chewing each mouthful thirty times will do more to cure dyspepsia than all medicines combined.

The Sense of Hearing. — The organs of hearing are the ears. Each one consists of three parts, named the *external*

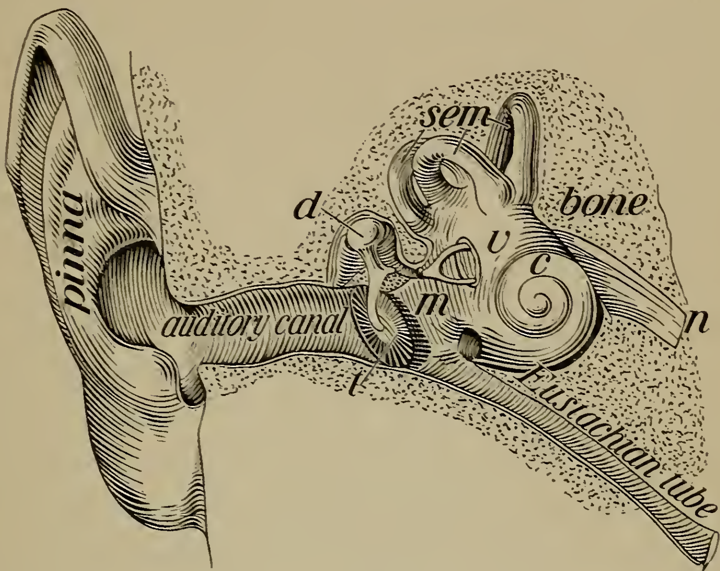


FIG. 157. — Temporal bone cut open to show the bony internal ear. *c*, cochlea; *v*, vestibule; *sem*, semicircular canals; *m*, middle ear; *d*, malleus; *t*, tympanic membrane; *n*, auditory nerve. The internal and middle ear are shown about double natural size.

ear, the *middle ear*, and the *internal ear*. The external ear is composed of the *pinna*, projecting from the side of the head, and the tube, an inch long, called the *auditory canal*, extending inward. Across the inner end of the canal is a thin membrane, named the *tympanic membrane*.

The cavity of the middle ear, or *tympanum*, also called *ear drum*, is nearly large enough to contain three pennies standing close together on their edges. It contains air

which may pass in and out through the Eustachian tube leading to the throat. The mouth of the tube is usually closed, but it opens every time a bit of food or even saliva is swallowed. Three bones, the *malleus*, or hammer, *incus*, or anvil, and *stapes*, or stirrup, form a chain stretching from the tympanic membrane to another membrane closing an oval opening into the internal ear (Fig. 157).

The *internal ear*, or *labyrinth*, is composed of several irregular connected cavities in the temporal bone containing within them correspondingly shaped membranous sacs supporting the end organs of the nerve of hearing. The three parts of the internal ear are the *vestibule*, *cochlea*, and the three *semicircular canals*. The bony cavities are filled with a watery fluid, called *perilymph*, serving to float the delicate membranous parts containing a similar fluid, the *endolymph*.

The fluid in the bony vestibule about the size of a pea is separated from the cavity of the tympanum at one place by a mere membrane to which is fixed the foot of the stapes. The semicircular canals are bent tubes placed at right angles to each other. They have nothing to do with hearing, but enable one to balance the body and know its position even with the eyes closed.

The *cochlea*, so named from its resemblance to a snail shell, is a coiled tube having three coils, with those nearer the center becoming successively smaller and more elevated. On the interior of the membranous cochlea is located the sense organ of hearing, consisting of columnar cells with hairlike processes projecting into the endolymph.

How Sound is Heard. — The striking of a hard object, the crack of a gun, or any other similar action disturbs the air and causes in it waves like the waves produced in water by a stone cast into a quiet pool. The sound waves are vibrations of particles of air which knock against the delicate tympanic membrane. This causes motion in the chain of bones of the middle ear, and these in turn transmit the vibration to the perilymph of the inner ear, touching the membrane attached to the foot of the stapes. The waves in the perilymph beat on the delicate membranous part of the cochlea, and thus make vibrations in the endolymph which affect the hairlike processes on the cells at the termination of the nerve fibers of hearing. These fibers, forming the *auditory* or *eighth cranial nerve*, conduct the stimulus to the brain.

The Care of the Ears. — Hard objects, such as pencils and sticks, should not be pushed into the external ear for fear of breaking the ear drum. The wax, which tends to keep insects and dirt from lodging on the tympanic membrane, sometimes collects in too large quantities in the canal. It may then be removed with the round end of a wire hairpin. Insects finding their way into the ear may be killed or made to come out by putting in a few drops of warm soapy water while the patient is in a reclining position, with the affected ear uppermost. In ten minutes the ear may be turned down on the pillow, when the water will flow out and carry the insect with it.

Deafness. — The ear is a very delicate organ, and injury to any of its parts may result in deafness. A box on the ears may rupture the ear drum, but in many cases nature will mend this break. Closure of the Eustachian tube by

catarrh, so that the pressure of the air in the middle ear cannot be made equal with that outside, sometimes causes partial deafness. A growth of germs in the tympanum, producing an inflammation, as in running ears, may make the three little bones grow together solidly at their ends, and then they cannot move freely to transmit sound. More than half of the school children in the United States suffer from a defect in the ears, eyes, nose, or throat.

The deaf and dumb are unable to hear because the sense organ in the cochlea is imperfect. Some cases of deafness resulting from disease or accident can be cured, but one should never pay attention to the numerous advertisements in newspapers and magazines offering to cure deafness. They are the words of quack doctors who rob people of thousands of dollars and are likely to damage the ear seriously. An honest physician does not advertise a sure cure for deafness, but does all in his power to enable his patients to recover their hearing.

Questions

1. Explain the nature of sense organs. 2. Name eight senses. 3. Name the senses having organs located in the skin. 4. Of what use are the sense organs? 5. Why do we not feel the particles of food brushing against the sides of the stomach? 6. Describe the sense organ of smell. 7. Explain the sense of taste. 8. Give the three parts of the organ of hearing. 9. Describe the middle ear. 10. Name the three parts of the internal ear. 11. How is the fluid arranged in the internal ear? 12. Of what use are the semicircular canals? 13. Explain the location and use of the cochlea. 14. Describe how sound is heard. 15. Give some points in reference to the care of the ears. 16. What may cause deafness? 17. Why is it unwise to patronize doctors who advertise to cure deafness? 18. Test each ear by closing one with the finger and then listening to the tick of a watch in a distant part of the room.

Suggestions for the Teacher

1. Let the children test the sense of taste on different portions of the tongue by placing bits of sugar and salt on various regions of the tongue.

2. Test the hearing of the pupils by placing a ticking watch at varying distances from them. Ask the pupils to note through which ear they hear the more distinctly. The test can be made by closing one of the ears with the finger. It is important that the teacher may discover any defects in the hearing among the children, as dullness and apparent stupidity are often due to some diseased condition of the ears which may in early life be corrected by a physician. The children who do not hear distinctly should always be given the front seats.

3. The teacher may render a great service to any pupil partially deaf by talking the matter over with the parents and impressing upon them the danger of patronizing quack doctors, and the need of an immediate examination and advice by a physician. It is well to remember that in many cases partial deafness has resulted from adenoid growths described on page 147.

XXII. THE SENSE ORGANS (*Continued*)

THE EYE

The Location of the Eye. — The dome-shaped cavities in the front of the skull and just below the region of the eyebrows are the *orbital cavities*, in which the eyeballs are lodged. Thick layers of fat within each cavity make a secure resting place for the eyeball, which is held loosely by six muscles and the optic nerve. The *optic*, or second pair of cranial nerves, pass through holes in the skull to the brain and serve to convey the impressions made by light.

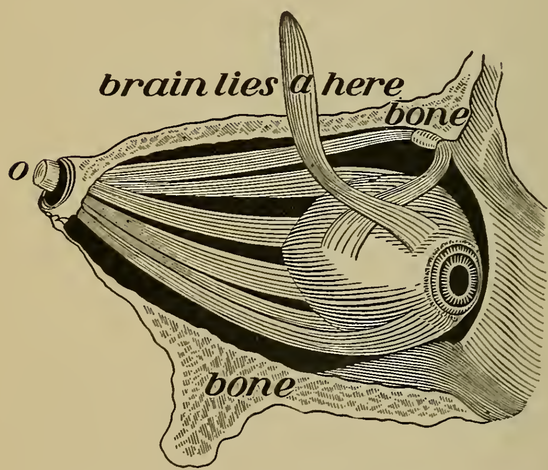


FIG. 158. — Side of the orbital cavity cut out to show the muscles moving the eyeball. *o*, optic nerve ; *a*, muscle cut loose.

How the Eyeball is Moved. — Four muscles attached to the upper, lower, outer, and inner surfaces of the ball are connected with the bones in the back part of the orbit. These are called *recti muscles*, because they are straight. A contraction of the inner one turns the ball toward the nose, while the outer one pulls in the opposite direction,

and the upper and lower muscles turn the ball upward and downward respectively. Two *oblique muscles* give other motions to the ball. Cross eyes are caused by the inner recti muscles being stronger than the outer ones.

The Parts of the Eye. — The complete eye consists of the eyebrows, which prevent the perspiration from running down into the eyeball, the eyelids, which protect the eyeball in front, and the eyeball itself. The *eyeball* is nearly spherical, and consists of an outer wall one tenth of an inch thick filled with three transparent substances, called *humors*. As the eye of a cow, pig, or cat has the same structure as a human eye, the dissection or cutting apart of the eyeball of any one of these animals will be a great help to pupils in their study of the organ of sight.

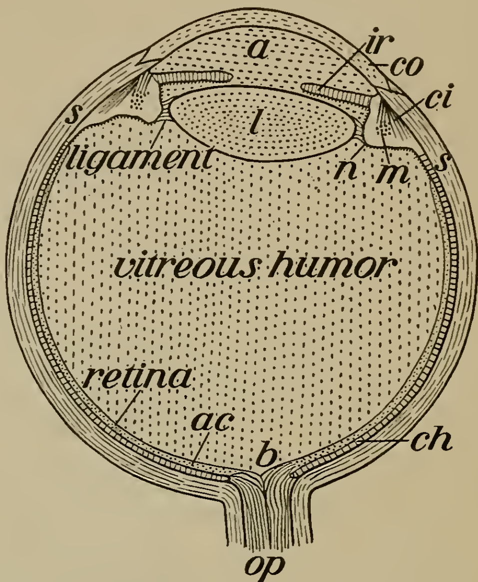


FIG. 159. — Horizontal section through the eye. *a*, aqueous humor; *ac*, fovea; *b*, blind spot; *ci*, fibers of ciliary muscle; *co*, cornea; *ch*, choroid coat; *ir*, iris; *l*, crystalline lens; *n*, ciliary processes; *op*, optic nerve; *s*, sclerotic coat.

The Walls or Coats of the Eyeball. — The wall of the eyeball is composed of three coats. The *outer coat* consists of the tough and thick *sclerotic* part behind, and the transparent *cornea* in front. The *middle coat*, about as thick as paper, is formed largely of the black *choroid* portion, con-

tinuous in front with the *iris* appearing blue, gray, or brown according to the color of the eye. A circular opening in the center of the iris is the *pupil*, through which light passes to the interior (Fig. 159). By means of muscular fibers forming part of the iris the pupil is made to vary in size so as to regulate the amount of light reaching the inner coat of the eye. A bright light diminishes the size of the pupil. The *inner coat* of the eyeball is the *retina*. It is thinner than the paper of this book, very tender, and of a pinkish white color. It is made of connective tissue and nerve matter, and forms the end organ of the optic nerve.

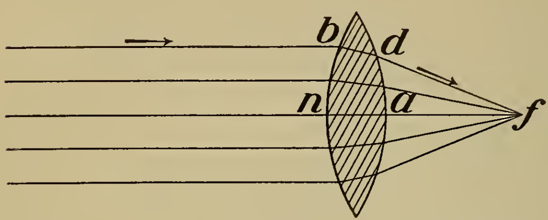


FIG. 160. — Diagram showing how the convex lens *na* brings the rays of sunlight to a focus at *f*. Note how the ray is bent at *b* and also at *d*, while the ray at *n* or *a* is not affected.

The Humors of the Eye. — The interior of the eyeball is divided into two chambers by the most solid humor, called the *crystalline lens*. The *anterior chamber*, between the cornea and lens, is filled with a watery fluid, known as the *aqueous humor*. The much larger *posterior chamber* is occupied by the *vitreous humor*, which appears like a colorless jelly.

If the posterior half of the wall of a cow's eyeball, freshly secured, is cut away with the scissors and the ball then laid so that the cornea rests on fine print, the letters will appear greatly magnified. The crystalline lens, which is held in place by a delicate ligament attached where the cornea unites with the sclerotic coat, may be

removed and supported on a paper with a small hole and used temporarily for a magnifying glass.

The Nature of Light. — Light is produced by the waves or vibrations of a substance called *ether*. It is present in all space, and even where air does not exist. The waves of ether aroused by the sun or lamp make impressions on the retina, which are transmitted to the brain by the fibers of the optic nerve. Many objects, such as a pencil or a table, have no power in themselves to produce light, but they reflect or throw back the light waves started by the candle or sun.

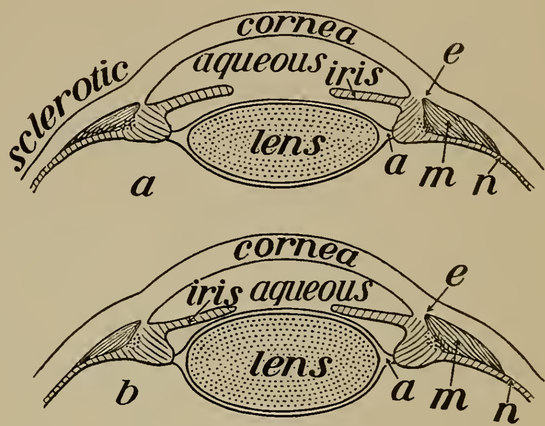


FIG. 161. — Diagram of the shape of the lens; *A*, when viewing far objects; *B*, when viewing near objects; *a*, ligament of the lens; *e*, attachment of ciliary muscle *m* which in *B* is contracted so as to draw forward the choroid coat at *n* and thus loosen the ligament of the lens.

The waves of light are like the waves in water caused by tossing a stone into it, but they travel much faster. The rate of progress is about 186,000 miles per second. They travel in straight lines. Each of the millions of lines of light radiating from an object in all directions is called a *ray*. Substances like glass, which permit the rays of light to pass through them readily, are said to be *transparent*. A ray of light passing through a glass with curved surfaces may have its direction changed, as seen in the diagram.

The Bending of the Rays of Light. — A ray of light passing through glass whose surface it does not strike perpendicularly is bent out of its direct course. A piece of glass whose opposite surfaces curve outward forms a *convex lens*, while one with the opposite surfaces curving inward toward each other is a *concave lens*. Rays of light passing through a convex lens are made to converge so that all meet in one point called the *focus*, as shown in the figure.

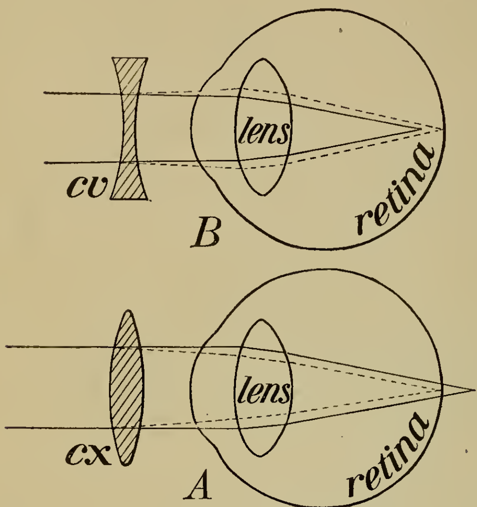


FIG. 162. — Diagram showing how nearsightedness as in *B* and farsightedness as in *A* can be corrected by glasses. The dotted lines show how the rays of light are affected by the glasses, while the unbroken lines show the direction of the rays when the glasses are not present.

The Process of Seeing. — In order that the retina may be stimulated in a way to give the brain a clear image of any object, the rays of light coming from the object must be made to meet at one point on the retina. To effect this, the crystalline lens is convex. Since the rays passing through the lens near its edge are bent more than those passing through near the center, it is necessary to have behind the crystalline lens another lens, the vitreous humor. This together with the aqueous humor so acts as to bring the rays to one point on the retina.

The eyeballs are so held by the muscles that the rays of light coming from an object are focused on a corre-

sponding area in each eye. This area, called the *fovea*, or point of acute vision, is a quarter of an inch to the outer side of where the optic nerve pierces the eyeball. After slightly rotating one eyeball by pushing on it with the finger, the rays of light will not strike the fovea in that eye, and consequently the object will appear double.

The Power of Accommodation. — The change frequently taking place in some parts of the eye in order that it may see distinctly objects that are near by or those far off, is called *accommodation*. After reading several hours, the eyes grow tired, because a constant effort must be made to render more curved the convex surfaces of the crystalline lens. This greater bulging of the lens is necessary to bring the rays of light from a near-by object to a focus on the retina. The bulging is produced by contracting the ring of muscular fibers, the *ciliary muscle*, lying in the sclerotic coat at the edge of the cornea where the ligament of the lens is fastened. The contraction of the ciliary muscle loosens the ligament which, when tight, tends to flatten somewhat the curved faces of the lens (Fig. 161).

Y F E V

Fig. 163. — Snellen's test letters. These should be seen distinctly by a correct eye at a distance of twenty feet.

Nearsightedness. — This is usually due to the eye being longer than normal from before backward. The rays of light are brought to a focus before they reach the retina. Sometimes, however, the eye is of usual length, but the lens or cornea is too convex and therefore focuses the light before it reaches the retina. This defect is seldom

present in children under four years of age. It is produced in later years by pressure of the muscles on the sides of the eyeballs whose coats have become weak. Nearsightedness is remedied by wearing double concave glasses, which prevent the rays of light from coming to a focus too soon.

Farsightedness. — This is caused either by the eye being shorter than normal from before backward or by

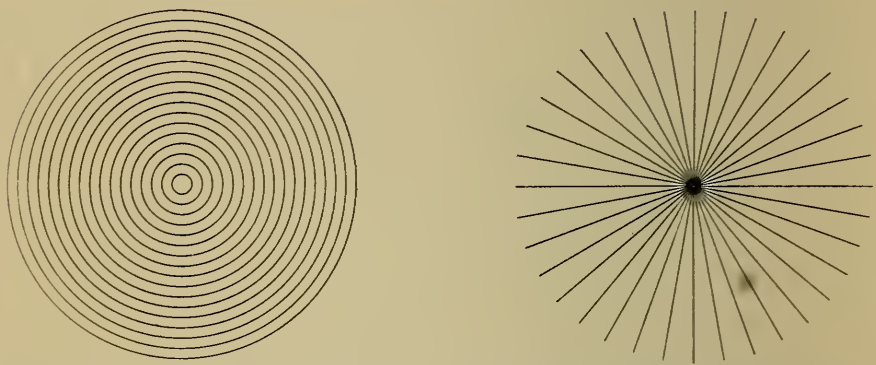


Fig. 164. — To test for astigmatism. When looking with one eye at either figure, if some of the lines appear blurred, astigmatism is present.

too little curvature of the surfaces of the lens. This is an exceedingly common ailment among persons over 50 years of age. In young people the lens is soft, and therefore its shape is easily changed by tightening or relaxing the ligament enveloping it. The eye at rest has the lens so shaped as to focus the light from objects a hundred feet or more distant. Farsightedness is remedied by the use of convex glasses.

Astigmatism. — This is a serious defect in the eye, caused by the unequal curvature of the surface of the cornea or of the lens. That is, the curve of the line

passing across the center of the cornea from side to side is greater or less than the curve of a line extending up and down across the center of the cornea. Headache and the smarting of the eyes after continued use are signs of astigmatism. It may be remedied by glasses, which can be provided only by an oculist after the eyes have been carefully measured.

Color Blindness. — One out of every 20 male persons is color blind, while only one out of every 200 females is similarly afflicted. Color blind people are in most cases able to distinguish all colors except red and green with their various shades. No one who is color blind can become a railway engineer or a pilot on a vessel. Its cause is unknown, and it cannot be cured.

Tears. — The tears, composed of water and a very slight amount of salts, are continually formed by the *lachrymal gland* in the upper and outer part of the orbital cavity just within the rim of the orbit. It is about as large as a peanut seed. The tears, which are for the purpose of moistening the cornea and eyelids, are carried away by the tear duct. This leads from the inner corner of the eye through the bone into the nose. Certain emotions cause the tears to be formed so abundantly that they overflow and run down the cheek.

How to keep the Eyes Strong. — Examination of the children in one of the large city schools showed that at six years of age four fifths of them had perfect eyes, and only four out of a hundred had serious defects in sight. At eight years of age three fourths of the children possessed perfect eyes, and eight out of every hundred had some bad defect in the eye. At eleven years of age

eleven out of a hundred had some serious eye trouble, and only a little over two thirds had perfect eyes. These facts show that most people are born with good eyes, but they injure them by use in a wrong way.

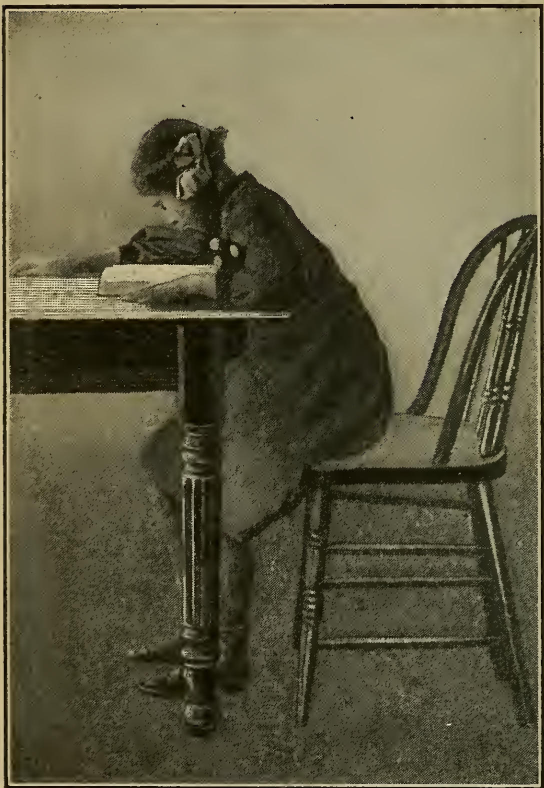


FIG. 165. — Portrait showing how the eyes may be injured.

The book should never be held nearer to the eyes than one foot, and the reading of print finer than that used in this book should be avoided by young people. The fine print used as footnotes and explanations of the main text in many textbooks and even physiologies is responsible for starting many eyes on the road to ruin. Trying to see in a dim light and leaning the head forward while reading cause pressure on the eyeball and produce nearsightedness. While using the eyes, the head should be held erect and the light be so arranged as not to come from in front. The aching or smarting of the eyes, pain in the head or back of the neck, frowning, or dizziness indicate that the eyes are not in perfect

working order. Out of 58,948 children whose eyes were tested in New York, 17,928 were suffering from defective vision.

No person should use glasses until discomfort is experienced after using the eyes one or two hours in reading print as coarse and clear as that in this book. In seeking a remedy for poor sight, one should consult a physician and not take the risk of having the eyes permanently injured by purchasing glasses from a quack doctor. Quacks may be known by the large advertisements they insert in newspapers or magazines.

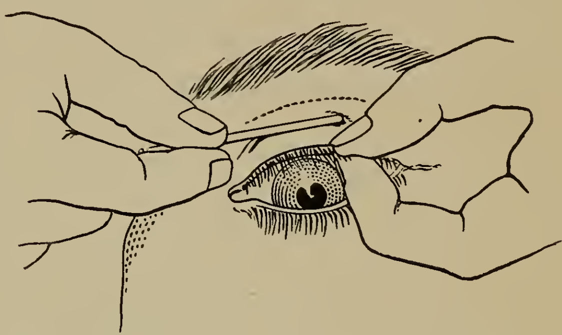


Fig. 166.—Method of turning the eyelid up to remove dirt.

The Common Injuries to the Eye. — Cinders and bits of other hard substances often get beneath the lids of the eye. They irritate the delicate transparent membrane lining the lids of the eye and passing over the cornea. By having the patient look downward one may seize the edge of the upper lid and turn it backward over a rounded match stick. The particle of matter can then be removed with a corner of a clean handkerchief or a bit of absorbent cotton wound around the head of a pin. The lower lid may be merely drawn down to see and clean off the surface.

When the eyes are red or inflamed from any cause, some relief may be had by bathing them several times daily with a solution of boracic acid, made by dissolving

in a teacupful of water as much boracic acid as will lie on a silver half dollar.

Sore eyes are usually much relieved by being washed out with the boracic acid solution, because this tends to kill the germs causing the trouble. Care should be taken that the germs in the sore eyes do not get on pencils, towels, or handkerchiefs used by other persons and thus make their eyes sick.

Cataract is a serious affection which may produce complete blindness. It is due to the crystalline lens becoming opaque. The removal of the lens and the use of proper glasses often remedy the difficulty.

How Narcotics Affect the Sense Organs. — The use of tobacco daily seems in some degree to affect the sense organs of the mouth so as to lead to a desire for strong drink. Much chewing and smoking tend to lessen the sense of taste. Hearing, as a rule, is but little injured by either tobacco or alcohol, though occasionally a catarrh extending up the Eustachian tube to the middle ear may be made more severe in the young by the use of cigarettes. Excessive smoking is likely to decrease the keenness of the sense of smell, because the delicate mucous membrane containing the olfactory organs is irritated by tobacco smoke.

It has been reported that the excessive use of tobacco causes wasting of the optic nerve leading from the eye to the brain. Late investigations, however, show that this is probably not true. Nevertheless frequent smoking in the young has been known to affect the sight seriously. Dr. Alfred Woodhull, of the United States Army, says : "Tobacco is liable to render vision weak and uncertain,

causing objects to appear nebulous, or it creates the sensations of floating spots." One well-known eye specialist alone reports 35 cases of injured vision produced by the continual irritation of the optic nerve by tobacco. Dr. McSherry says when sight fails in smokers and no change in structure can be seen, tobacco poisoning may be assumed. Candidates for the United States Naval Academy rejected on account of poor eyesight have in most cases admitted using tobacco while young.

The period of life before twenty is the time when the sense organs are most markedly affected by the unwise use of tobacco and alcoholic drinks. Even later in life, narcotics may do lasting injury to the senses. The use of much liquor produces bloodshot eyes, because the muscles of the walls of the arteries are relaxed and so become enlarged. Long use of intoxicants has been known to do permanent injury to the optic nerve, which was probably due to the paralyzing effect of the alcohol on the nerves controlling the blood vessels of the head.

Questions

1. Explain the location and attachments of the eyeball. 2. How is the eyeball moved? 3. Name the parts of the eye. 4. Name the parts composing the three coats of the eyeball. 5. Describe the retina. 6. What is the color of your iris and what is its use? 7. Name the three humors. 8. Explain the nature of light. 9. By means of a drawing show how the rays of light are bent in passing through a lens. 10. Describe the process of seeing. 11. What defects in the eye cause near sight? 12. How may near sight and far sight be remedied? 13. What is color blindness? 14. Explain the formation of tears. 15. Give facts showing that the eyes are more perfect in children than in older ones. 16. What may help keep the eyes in good condition? 17. How may particles of dirt be

removed from beneath the eyelids? 18. What care should be given sore eyes? 19. What effect has tobacco on the sense organs? 20. At what period of life are narcotics liable to do most injury to the sense organs?

Suggestions for the Teacher

1. Several eyes of pigs or cows may be secured from the butcher. Note the attachment of the several muscles to the tough sclerotic coat. In very cold weather one or two eyes should be left out over night to freeze, or they may be frozen in a few hours in a mixture of cracked ice and salt. With a sharp knife cut one of the frozen eyes through the middle from before backward, and note the arrangement of the three humors and coats, and then place the eye in a dish of pure formaldehyde solution. A fresh eye should be cut open from side to side with a pair of sharp-pointed scissors. Keep the point of the blade near to the inner surface of the eyeball. The vitreous humor and lens may be turned out together, and when laid on fine print, will show considerable magnifying power. The retina appears as a thin, grayish, very tender lining of most of the eyeball. Note the black choroid as thin as paper.

2. Show with a magnifying glass or convex lens of any kind how the rays of light are brought to a focus by holding the glass in the sun at the right distance from a piece of paper to show a spot of light as large as a pin's head on the paper.

3. Test the eyes of the pupils with Snellen's test letters, and note how close the pupils hold the book to the eyes when studying. Report any defects to the parents and advise that an oculist be consulted. Insist that the pupils maintain the right position in reading to avoid injuring the eyes. It is far more important that the pupil should have perfect eyes and ears than that he should learn his lessons.

XXIII. THE CAUSE OF DISEASE

The Work of Parasites. — Only one in every forty persons dies of old age. About twice that number meet death by accidents, while disease is responsible for over nine tenths of the mortality of the human race. The numerous diseases affecting man may be divided into two classes, known as *infectious* and *non-infectious*.

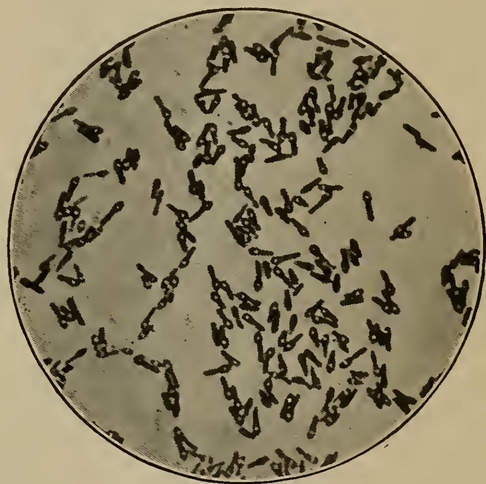


FIG. 167. — Germs that cause lockjaw. Photographed through the microscope.

The *infectious diseases* are caused by tiny plants or animals, called *parasites*, feeding upon the human body which is their *host*. These parasites, the smaller of which are commonly called microbes or germs, make one ill chiefly by means of their poisonous excretions. In Europe and America 60,000,000 people are annually laid prostrate by infectious diseases which result in over 3,000,000 deaths.

Kinds of Diseases. — Such infectious ailments as consumption, smallpox, and scarlet fever which may be contracted by breathing in the germs floating in the air are

called *contagious diseases*, because the healthy acquire the disease by coming near where the sick are or have been. Maladies like yellow fever, lockjaw, and malaria belong to the group of *non-contagious* diseases for the reason that persons living in the same house and even sleeping in the same bed with the sick do not become ill unless a mosquito or a sharp instrument conveys the germs from the sick to the well.

Fig. 168. — Louis Pasteur.

The *non-infectious diseases* such as alcoholism, diabetes, insanity, and cancer are due to changed methods of work and growth on the part of cells in certain regions of the body. More people die from infectious diseases than from non-infectious. This means that most ill health results from tiny forms of life growing within our bodies.

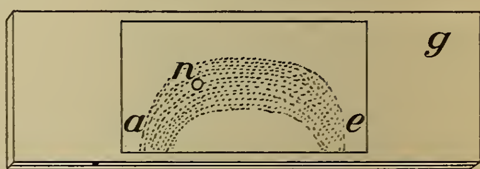


Fig. 169. — Glass slip *g*, to which the lower lip was touched at *a-e* as one would touch a cup in drinking. A fourth part of the circle *n* was photographed through the microscope, giving the picture as seen in Figure 170.

The Discovery of what causes Disease. — Several hundred years ago disease was thought to be due to evil spirits which took up their abode in the body. Here

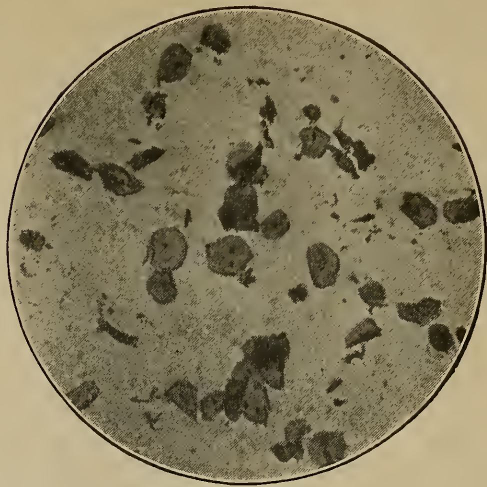


FIG. 170. — Numerous epithelial cells from the mouth left on the glass as described in Figure 169.

they produced continuous suffering until driven out by various devices such as beating the patient with a strap or giving him so-called medicine consisting of powdered human bones. Although for fifty years it has been thought by some that many diseases were due to bacteria, yet the fact that each of certain diseases is caused by a particular bacterium was not clearly proved until 1876. In that year Louis Pasteur, of France, showed that anthrax, a sickness of cattle, was caused by a rodlike plant. He secured a few of these plants from the blood of a sick cow, and planted them in broth, where they increased rapidly in number. A few were then injected under the skin of a healthy cow which soon after became sick. In her blood the same plants

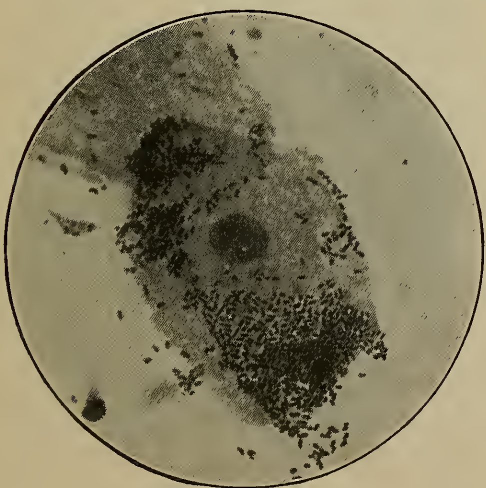


FIG. 171. — One of the cells like those shown in Figure 170 left by the lip on the glass. The 200 or more black bodies are bacteria.

were found in vast numbers. Dozens of similar experiments and the presence of these particular plants and no others in the blood of all animals with anthrax have made it certain that the disease is caused by this special germ. In a similar manner or by some other equally reliable method it has been shown that each of the following ailments is produced by its own particular kind of germ: diphtheria, typhoid fever, malaria, pneumonia, leprosy, lockjaw, hydrophobia, influenza, or grippe, erysipelas, and tuberculosis.

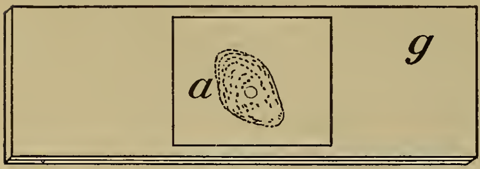


FIG. 172. — Spot *a*, on a glass slide *g*, touched with the thumb moistened from the lips as in turning the pages of a book.

There is no doubt that measles, scarlet fever, smallpox, and mumps are also produced by germs, but no one has yet been able to find them. Inasmuch as all infectious diseases may be prevented by keeping the germs out of the body, much effort has been made to learn how they gain entrance.

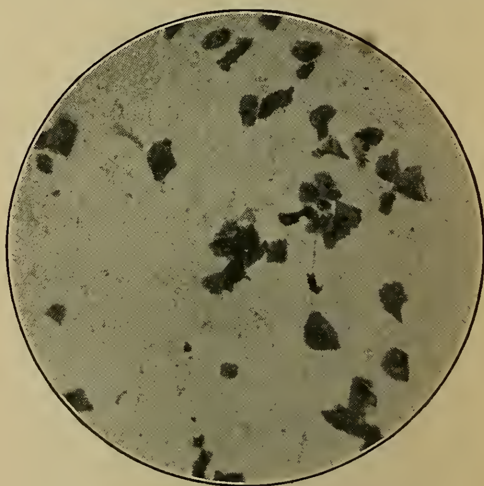


FIG. 173. — The fourth part of the circle in Figure 172, showing a score of cells from the lips. Photographed through the microscope.

How Germs enter the Body. — The germs of any contagious disease may be taken in by breathing, but other

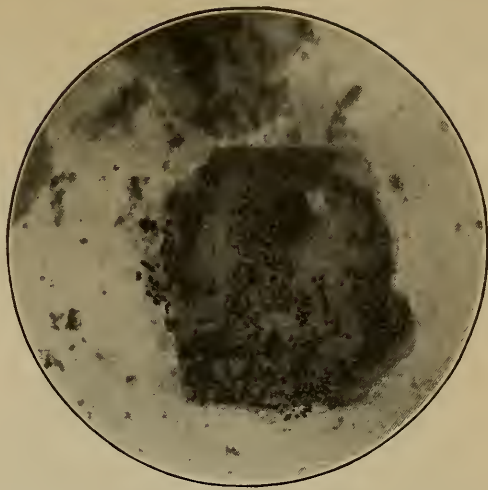


Fig. 174. — One of the cells like those left by the thumb on the glass slide, as shown in Figure 173. The hundred or more tiny black bodies are bacteria, always abundant on the lips. Photographed through the microscope.

channels of infection are also known. Influenza, or grippe, pneumonia, diphtheria, sore throat, and whooping cough are no doubt often contracted by a healthy person drinking from the same cup lately used by those just recovering from sickness. Numerous disease germs as well as harmless ones are present in the sputum of such patients. By examining with the microscope a glass touched by the lips, I have found over 20,000 bacteria. I have seen more than 5000 germs deposited on a glass slip by a single touch of a finger moistened with saliva to aid in turning the pages of a book. The fingers touching soiled books, clothing, pencils, or other things handled by the sick may convey the germs to the mouth. The number of days elapsing from the time the germs enter the body to the time when the disease appears is known as the *incubation period.*

Fig. 175. — Two flies feeding on spit containing millions of bacteria, many of which will be carried on their feet to the food on the table.

The Character and Incubation Period of Infectious Diseases

		Period of Incubation in Days
Non-contagious	Lockjaw	
	Yellow fever	
	Hydrophobia	
	Malaria	
	Sleeping sickness	
	Blood poisoning	
	Dysentery	
	Peritonitis	
	Appendicitis	
	Trichinosis	
Slightly contagious	Diphtheria	1–6
	Tuberculosis	20–10,000
	Typhoid fever	8–20
	Leprosy	unknown
	Pneumonia	unknown
	Grippe	1–5
	Cholera	1–10
	Bubonic plague	3–12
Very contagious	Scarlet fever	1–7
	Smallpox	8–16
	Measles	8–16
	Mumps	14–21
	Chicken pox	12–16
	Whooping cough	8–16
	Typhus fever	6–12

How the Germs of Tuberculosis enter the Body. — Tuberculosis, commonly called consumption, the most common of all maladies, was until 1905 thought to be generally acquired by breathing the germs into the lungs with the air. It has lately been shown that the germs more often reach the lungs by passing through the walls of the alimentary canal into the lymph vessels and thence by the

blood to the lungs. Here the thin-walled capillaries permit the germs to pass through into the tissues. The germs once in the body may lie there without growing for twenty years.

The lungs of ten healthy guinea pigs fed on milk containing tubercle bacilli became in about two months badly affected with tuberculosis. These germs, injected under the skin of hogs or cows, in most cases produce disease of the lungs. Calves fed on the milk of tuberculous cows only a few days acquire tuberculosis of the lungs. The sputum of tuberculous patients contains millions of the disease germs. These may get on the furniture, may be carried by flies from the spittoon to food, or may dry and be blown about in the wind. In any case they are liable to reach the mouth of a healthy person.

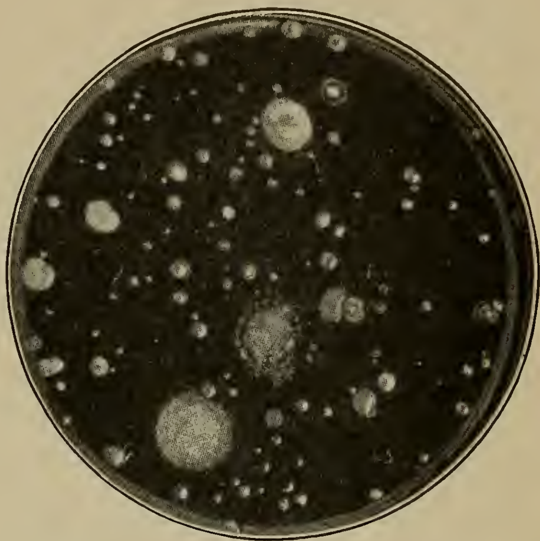


FIG. 176. — A dish of beef broth jelly on which a fly was allowed to walk for a few minutes. Wherever a germ was rubbed off from the fly's feet, it grew and made millions of germs, appearing as a white spot the next day. The white spots in the picture therefore show how many germs that fly would have left on food over which it crawled.

The Danger from Tuberculosis in Cows. — A large number of cows have tuberculosis, but it is often not detected by a farmer until the animals become very sick. Nearly one

third of the cattle of Great Britain are said to be tuberculous, and investigations show that there are not less than a quarter of a million tuberculous cows east of the Mississippi River. Fortunately less than half of them shed the germs in their milk, but vast numbers of the germs are found in their manure. This often soils the

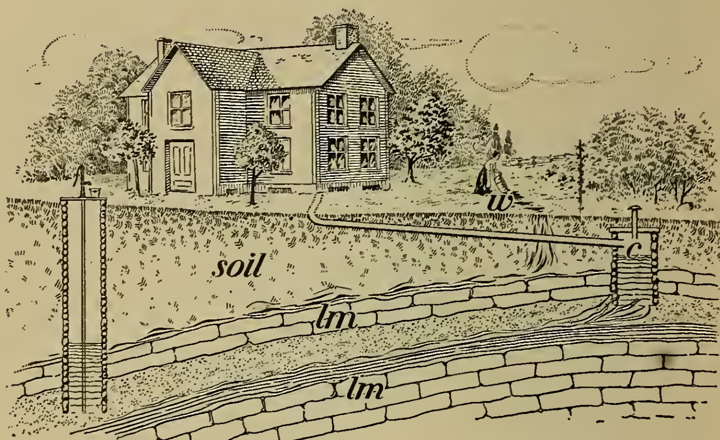


Fig. 177. — Showing how disease germs often reach the drinking water. *c*, cesspool; *lm*, layer of rock; *w*, wash water.

cow, then becomes dry, and is later brushed off into the milk pail.

Germs of tuberculosis have been frequently found in milk, and numerous cases are on record where the use of milk from sick cows has given the disease to children. Tuberculosis germs lodging in the lungs produce consumption or *phthisis;* in the lymphatic glands, *scrofula;* in the skin, *lupus;* in the bone, *white swelling*, *hip-joint* disease, or other trouble; and in the membranes of the spinal cord or brain, *meningitis*.

Typhoid Fever and Water. — The germs of typhoid fever gain access to the body in most cases with food or water. In 200 epidemics, during each of which from 10 to 1300 people were affected with the fever, 71 per cent were caused by water and 28 per cent by milk. In the winter of 1885 the excreta from a typhoid patient were cast out on the snow along the mountain stream supplying Plymouth, Pennsylvania, with water. During the first thaw of spring, the excreta were carried with the melted snow into the reservoir, and two weeks later numerous cases of fever appeared daily in the town until there was a total of 1104 persons sick. When an investigation showed that none who had used water from other sources than the mountain stream were affected with the fever, there was no doubt about the cause of the epidemic. Other serious epidemics have occurred through the use of polluted water as follows: in 1893–1894 Windsor, Vermont had 130 cases, Grand Forks, North Dakota had 1245 cases, and Montclair, New Jersey had 108 cases; in 1895 Stamford, Connecticut had 406 cases; in 1903–1904 Leadville, Colorado had 450 cases, Marshaltown, Iowa had 418 cases, Butler, Pennsylvania had 1364 cases, and Watertown, New York had 5000 cases.

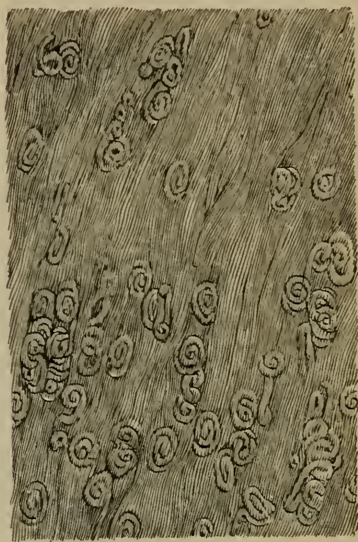


FIG. 178. — Drawing of a piece of deltoid muscle of a girl who ate pork not well cooked, and died of trichinosis. Note the many-coiled trichina. Magnified.

The scattered cases of typhoid occurring in nearly all communities may be due to a very slight pollution of the water, to flies carrying the germs from human excreta to food, or to eating raw oysters, lettuce, and celery, in or upon which the germs may lodge.

Typhoid Fever transmitted by Milk. — Many severe epidemics of fever have resulted from infected milk. As the cows never suffer from this malady, it is evident that the germs must get into the milk from an outside source. This source is often the water used from a polluted well or stream to wash the cans. A single germ remaining in the water, clinging to the can, is capable of developing so rapidly in milk as to give rise to over 1,000,000 germs in 12 hours. Frequently germs have been known to get into the milk from the hands or clothes of those who have just recovered from the disease, or from those who have been nursing a typhoid patient.

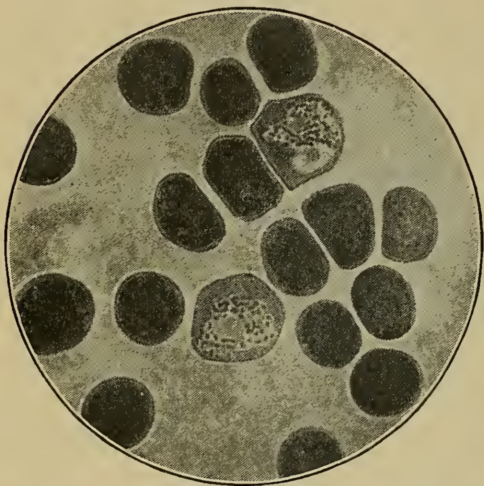


FIG. 179. — Two malarial germs, each in a blood corpuscle. Magnified.

Infectious and Non-contagious Diseases. — The germs causing lockjaw are present in the soil and may reach the tissues through any kind of a wound, but they grow only when the air is shut off from them. Boils or any other inflammation are the result of bacteria gaining entrance and growing beneath the skin. Several diseases,

including hydrophobia, trichinosis, malaria, yellow fever, and sleeping sickness, are produced by minute animals finding their way into the blood. Hydrophobia usually results from the bite of a rabid dog with the germs in his saliva. Trichinosis comes from eating pork not well cooked and containing little worms. The parasites causing malaria or yellow fever can reach the body tissues only by the bite of certain species of mosquitoes. The malaria mosquito may always be recognized by the fact that it has spotted wings and holds its body oblique to the surface on which it alights, so that it appears to stand on its head.

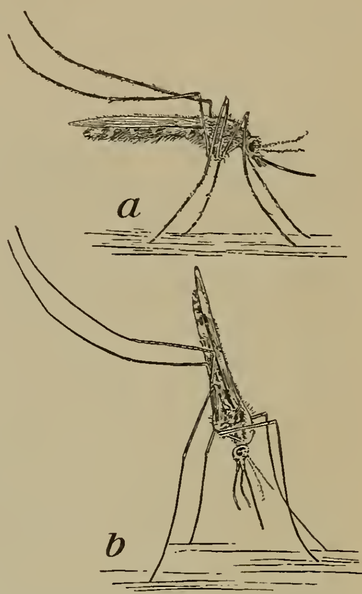


Fig. 180. — Position taken by a common mosquito (Culex) *a*, and by a malaria mosquito (Anopheles) *b*, when alighting. Note that in the malaria mosquito the two palpi just below the sucking bill are about four times as long as in the common mosquito. After Howard.

Cholera infantum and other diarrheal diseases often result from the use of unclean milk and water or from food vessels in which certain bacteria have developed.

Alcohol and Disease. — The continual use of liquor weakens the cells of the body which naturally kill off the harmful germs. Late investigations clearly show that those consuming alcoholic drinks, except in very small quantities, are not only attacked sooner than others by infectious diseases, but are also less able to resist the effects of the disease. The greatest Russian scientist

has lately said that alcohol paralyzes those elements in the body tending to prevent disease. By experimenting he found that in exposing rabbits to certain disease germs only those animals which had been given alcohol ever contracted the disease.

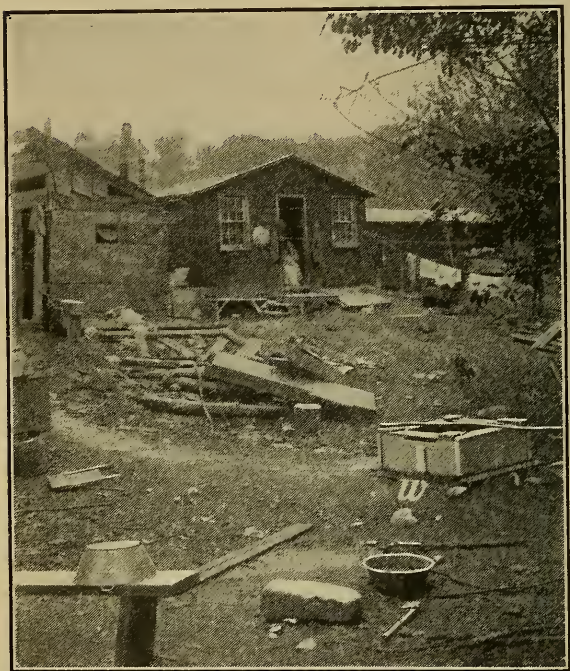


Fig. 181. — Well, *w*, containing very impure water causing intestinal sickness. Analysis of the water showed many germs indicating that it was dangerous for use.

Constant users of alcoholic drinks are especially liable to fall a prey to diseases of the respiratory system. Alcohol so weakens the body cells which ordinarily destroy the germs of pneumonia that the disease is often able to gain a hold in the systems of drinkers. The enlargement of the blood vessels of the lungs produced by the stupefying effect of the alcohol increases the tendency to inflammation.

Indulgence in the use of beer, wine, and whisky is considered to have such a serious effect on the tissues of the body that The International Congress of Tuberculosis in 1905 passed the following resolution: "In view of the close connection between alcoholism and tuberculosis, this

Congress emphasizes the importance of combining the fight against tuberculosis with the struggle against alcoholism."

Diseases of the liver, kidneys, blood vessels, and heart often result from the long-continued use of beer or whisky.

Questions

1. Of every hundred deaths how many result from disease? 2. What is the cause of infectious diseases? 3. Give facts showing that infectious diseases result in much sickness. 4. What is a contagious disease? 5. Name some contagious diseases. 6. Name some infectious diseases not contagious. 7. How has it been shown that a special germ causes a special disease? 8. Name ten diseases caused by germs. 9. How may diphtheria, sore throat, whooping cough, and grippe be contracted? 10. How may the germs of some diseases be transferred to the leaves of a book? 11. Explain the incubation period of disease. 12. Name three diseases with short incubation periods. 13. Name two diseases with long incubation periods. 14. Name four very contagious diseases. 15. How do the germs of tuberculosis enter the body? 16. What facts show that the germs of tuberculosis getting into the blood are most likely to lodge in the lungs? 17. How do germs of tuberculosis get into milk? 18. What diseases are caused by the germs of tuberculosis? 19. How do the germs of typhoid fever enter the body? 20. Give facts showing that typhoid fever is generally acquired by drinking impure water. 21. How may flies be the means of causing typhoid fever? 22. How is it possible for milk to be the source of typhoid fever? 23. What cause lockjaw and hydrophobia? 24. How do the germs of malaria enter the system? 25. Give evidence showing that alcohol is a factor in producing disease.

Suggestions for the Teacher

Bulletins or pamphlets published by the State Board of Health should be distributed among the pupils and each one asked to write on one or two sheets of paper what he considers the most important things to be remembered in the bulletins. These bulletins may be had free in most states by requesting them from the State Board of Health at the capital of the state.

XXIV. THE PREVENTION OF DISEASE

The General Methods. — There are three general methods of preventing infectious disease. One way is to destroy the harmful germs continually passing out of the sick body with the excretions, and so prevent them from reaching the healthy. A second plan is to stop the disease germs scattered about by careless people from entering the body. A third means of keeping away disease is to develop in the body tissues a substance which has the power to destroy certain disease germs entering the system.

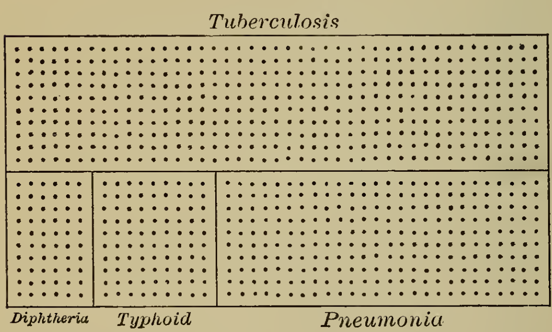


FIG. 182. — Diagram of a part of our nation's cemetery. The black dots represent the number of graves made daily for persons dying of the four diseases.

Destroying the Cause of Disease. — Until 1890 but little attention was given to the scientific prevention of disease. A sure method of restraining criminals from robbing and killing, is to keep them shut up in prisons or to kill them. Likewise, a certain method of preventing harmful germs from robbing some citizens of health and killing others is to destroy the germs when they escape from the body of the sick.

The bowel and kidney excretions of a person suffering from any of the contagious diseases should always be treated in a way to kill the germs. This may be done by adding to them four times the quantity of boiling water. The easiest and surest method of killing the germs is to add to the excretions an equal amount of formalin, made by mixing a teacupful of formaldehyde solution with a gallon of water. After adding the germ killers, called disinfectants, the material should stand a half hour before being disposed of in the usual way.

Fig. 183. — A receptacle frequently receiving the germs of grippe, tuberculosis, tonsilitis, and diphtheria to be distributed by flies.

Nearly 300,000 cases of typhoid fever occur annually in this country, resulting in about 40,000 deaths. Careful investigations have shown that three fourths of this suffering and loss of life was due to negligence in permitting the living typhoid germs in the kidney and bowel excreta of the sick to escape into the streams, wells, and soil. When a few years ago less than a thousand human beings on a vessel near New York lost their lives through the carelessness of others, the whole country was aroused and demanded that those who neglected their duty should be punished. Every year more than 100,000 men, women, and children lose their lives because others neglect their duty to kill the deadly germs passing from the bodies of those sick with contagious diseases.

It should be remembered that the disease germs often

continue in the excretions of the sick a week or more after recovery. Failure to kill the germs in the excreta of a single patient at Plymouth, Pennsylvania, resulted in 1104 cases of typhoid fever and many deaths. The sputum from the sick should be received on pieces of cloth or in well-greased pasteboard boxes covered to prevent the entrance of flies. The cloths or boxes should be burned at the end of each day. Flies are known to distribute the bacteria of consumption and typhoid fever.

The Isolation of the Sick. — A person suffering from a contagious disease should in most cases be quarantined. To *quarantine* means to isolate or to separate the sick from the well. The patient should be placed in a large airy room shut off from the rest of the house as much as possible and exposed to the sun, nature's germ killer. The hangings and carpets and all unnecessary furniture should be removed. Only the nurse and doctor are to be allowed to enter the room, and no clothing, dishes, or other articles should be taken from the room without being soaked in boiling water.

Disinfection of the Room. — *Disinfection* means the killing of the agents producing disease. An *antiseptic* is a substance which merely restrains the germs from growing. Ice, vaseline, a one-per-cent solution of carbolic acid, and a weak solution of boracic acid are common antiseptics. The three best disinfectants are a five-per-cent solution of carbolic acid, sunlight, and formaldehyde solution.

During the patient's sickness the room should not be swept, but wiped up daily with a cloth wrung out of a quart of water to which have been added two or three

tablespoonfuls of formaldehyde solution. When the patient has recovered, the room should be disinfected by closing it tightly, inserting wet paper in cracks and keyholes, and evaporating, by heating on an oil stove, two quarts of water to which has been added a pint of pure formaldehyde solution. In the absence of a stove the liquid may be sprinkled on the floor and bedding, but the results are not so good. The room should remain closed twelve hours, and then be exposed to sunshine and fresh air a day or two.

Disinfection of the Person. — After touching a patient or handling his clothing, the hands should be thoroughly washed with soap and water. The clothing used about the sick must be boiled before it is safe. Toys handled by a scarlet fever patient have been known to give the disease to others more than a year later. When the patient has recovered, his entire body, including the hair, should be carefully washed with water and plenty of soap. The outer clothes of the nurse should also be boiled, and in the more contagious diseases the hair thoroughly washed.

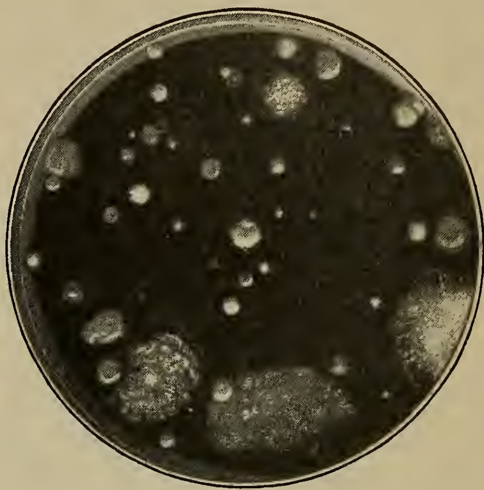


FIG. 184. — Why a sick room should not be swept. A dish of beef broth jelly was left open for two minutes in a room that was being swept. Wherever a germ fell it grew and produced millions forming a white spot. Therefore the white spots show how many germs fell on a circle two inches in diameter.

Keeping the Germs out of the Body. — With great care it is possible to keep out of the body the agents causing at least five of the infectious diseases. The germs responsible for *diarrhea*, *dysentery*, *cholera infantum*, and *typhoid fever* may generally be avoided by keeping flies away from food, and by drinking from clean vessels water or milk known to be pure, or by heating these fluids up to the boiling point. It is better to pasteurize the milk, as described in Chapter VII. The use of boiled drinking water in Philadelphia, Cincinnati, Cleveland, Louisville, Memphis, New Orleans, St. Louis, and Washington during the years 1900–1904 would have prevented 50,000 cases of typhoid fever. The use of boiled water in Pittsburg during the same five years would have prevented 10,000 cases of fever in that city.

Fig. 185. — Wigglers, the young of mosquitoes, trying to breathe through their air tubes sticking out on the surface of the water covered with oil.

The germs of *malaria* and *yellow fever* are easily excluded from the system by preventing the two kinds of mosquitoes carrying them from biting. As the young of these insects live only in quiet pools of water with no fish, their numbers may be much lessened by draining the

puddles and pouring out the water in tubs and old cans. Where this cannot be done the young may be killed by kerosene poured on the water, using one pint for every hundred square feet of surface.

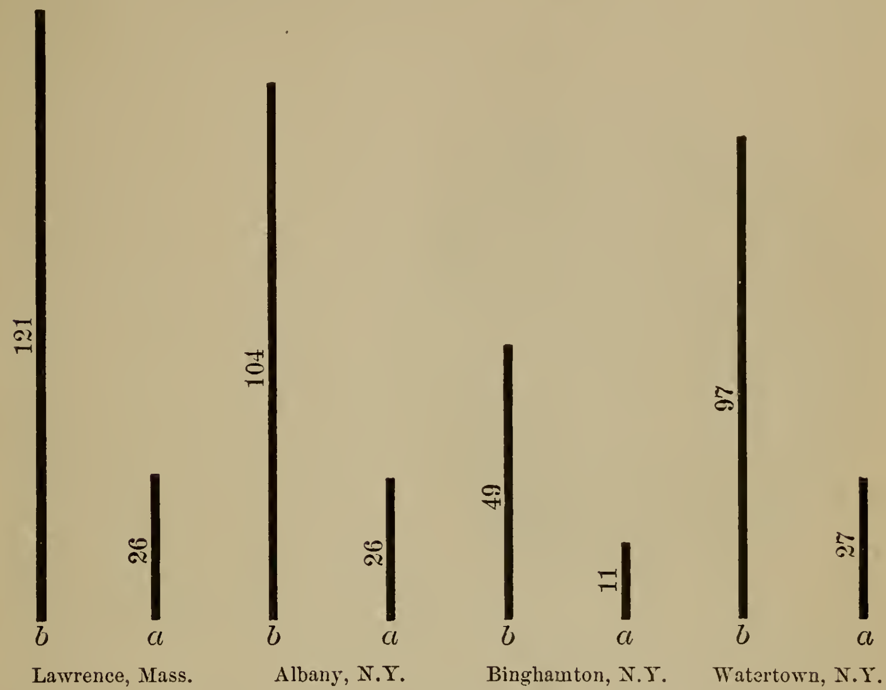


FIG. 186. — Diagram showing how supplying a city with good water lessens the sickness and death. The lines *b* above each city show the relative number of persons dying of typhoid fever before the water was filtered. The lines *a* show the number dying of typhoid after the water was filtered. The figures are the number of typhoid deaths occurring annually out of every 100,000 inhabitants.

The terrible *bubonic plague*, or *black death*, is also conveyed to man by the bite of a flea living on rats and man. Leprosy may be transmitted by the bite of bedbugs or fleas.

When near patients with typhus fever, scarlet fever, smallpox, grippe, measles, mumps, and chicken pox there

is no way of shutting the germs out of the system, because they become mingled with the air. The germs of diphtheria and tuberculosis are also likely to mingle with the air and enter the body of the healthy unless the patients use great care. The secretions of the mouth and nose should always be received into a cloth or special pasteboard cup and burned, and a cloth, to be later burned, should be held over the mouth while coughing. In quiet breathing no germs of any kind are given off.

Importance of Filtered Water. — Many cities getting their water from streams likely to contain disease germs pass the water through a layer of sand and coarse gravel to remove the germs. Most sand filters remove about ninety-eight per cent of the germs in the water. The small house filters, made of specially prepared material, take out all germs, but must be cleaned daily and boiled weekly to be effective.

Table showing the Saving of Life at Albany by Use of Filtration compared with Troy where during the Same Period the Water was not Filtered

Death rate per 100,000 in Albany, N.Y.	Before filtration 1894–1898	After filtration 1900–1904
Typhoid fever	104	26
Diarrheal diseases	125	53
Children under 5 yrs.	606	309
Death rate per 100,000 in Troy, N.Y.	**Water not filtered 1894–1898**	**Water not filtered 1900–1904**
Typhoid fever	57	57
Diarrheal diseases	116	102
Children under 5 yrs.	531	435

Since the city filter has been in use at Albany, New York, only one fourth as many deaths occur from typhoid fever as previously, and less than half as many deaths from diarrheal diseases.

Sewage Disposal. — The liquid waste resulting from housekeeping or manufacturing processes is named sewage. This should never be permitted to run direct into a stream because of the germs and poisons it may contain. Such germs as those of typhoid fever have been known to cause dozens of cases of sickness and death after being carried a week in the water. The sewage should be passed through a storage tank and oxidizing filter.

Fig. 187. — The germs causing pneumonia are the small oval bacteria usually in pairs. Photographed through the microscope magnifying 1000 diameters.

In the country or village, or when camping, galvanized iron cans should be used for the excretions from the body. A pint of dry earth thrown into the can daily will prevent odor and help change the waste matter to mineral earth. When the can is full the contents should be buried in a shallow hole in the garden or field.

The Power of the Tissues to kill Germs. — There is no doubt that disease germs get into the mouth and nose

every day. The bacteria causing sore throat and pneumonia have been frequently found in the mouth and throat of healthy people. These germs can provoke disease only when one becomes chilled so that his body cells are weakened and permit the intruders to get a start.

In health the nasal mucus, gastric juice, and other secretions destroy thousands of germs daily. The body

FIG. 188. — A healthful bedchamber for clear summer nights whereby the germ-killing power of the blood may be greatly increased.

cells manufacture and turn into the blood and other secretions of the body a substance capable of dissolving bacteria. There are also other agents in the blood called *opsonins* which affect the bacteria so that the white blood corpuscles are able to swallow them. This power of the blood and other secretions to kill germs varies in different persons, and also may be greater at one time than another in the same person. In adults this power to destroy the germs of scarlet fever and diphtheria is so

great that healthy persons over 30 years of age seldom take these diseases.

Alcohol and the White Blood Corpuscles. — It has for a long time been known that habitual drinkers when exposed to a contagious disease are much more likely to become ill than the total abstainers. The reason for this was not clearly understood until 1906, when it was found that the white blood corpuscles, which destroy disease germs, are stupefied by alcohol and thus prevented from doing their work.

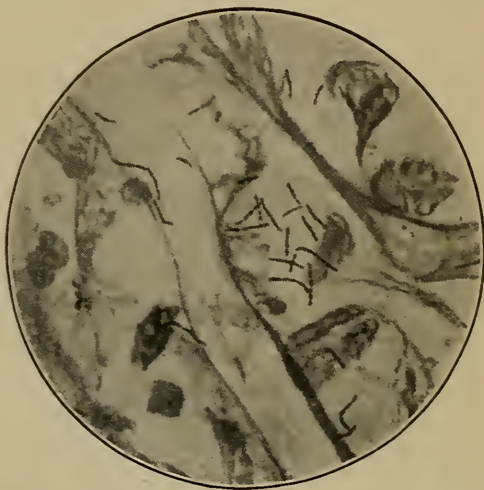


Fig. 189. — Germs of tuberculosis from the spit of a consumptive. Photographed through the microscope.

How the Body becomes Safe from Some Diseases. — In case disease germs reaching an individual have no effect on him, he is said to be *immune* to that disease. This *immunity*, or safety, depends upon the germ-killing power of the body fluids. This power may be developed in two different ways, one of which is known as the natural method, while the other is the artificial method. The natural method consists in the use of an abundance of nutritious food well chewed, plenty of sleep, fresh air night and day, and an hour of daily exercise. This is the most successful method of preventing tuberculosis and colds. The artificial method is by the use of *anti-*

toxins and *vaccines* secured from the domestic animals. Diphtheria, smallpox, lockjaw, and hydrophobia may always be prevented by this method if used in time.

Tuberculosis. — The tiny plants causing this disease are so abundant everywhere that it is impossible for those living in towns and cities to keep them out of the system. More than half of the people over 25 years of age have at some time had growing in their tissues the *bacillus tuberculosis.* The examination of a large number of bodies after death showed that 96 per cent of those between the ages of 18 and 30 had been infected with the germs; 50 per cent of those between the ages of 14 and 18; 33 per cent of those between the ages of 5 and 14; and 17 per cent of those between the ages of 1 and 5 years. In most of these persons, the germs had not multiplied sufficiently to cause any discomfort, because the germ-killing power of the body fluids had kept them in check. The fact that 400 people are dying daily in the United States from this one disease and that one third of all deaths occurring between the ages of 15 and 45 years result from tuberculosis shows the importance of trying to render the body immune.

Making the Body Safe from Tuberculosis. — Proper living will in 99 per cent of all well persons render the body capable of killing the germs of tuberculosis. The living or working rooms should be well ventilated, and the area of the open windows in the bedroom occupied by two should not be less than ten square feet in winter and twice as large in summer. Good food, including plenty of milk and eggs, should be taken. Exercise, especially such as calls into action the chest muscles and fills the lungs full of air, ought to be indulged in a half hour or

more twice daily. Eight hours of sleep with an extra nap after the midday meal are necessary. There should be no indulgence in alcoholic drinks.

Evidence that living according to the above plan will render one practically safe from tuberculosis is furnished

FIG. 190. — Sleeping quarters in the foreground at the sanatorium for consumptives at White Haven. Note that the rooms are wide open to the fresh air on three sides. Hundreds of patients have been cured here.

from three sources. Not one of those who follow these rules of life suffer from the disease. Three fourths of the half million persons with the disease in this country have been overworked or underfed or lived in poorly ventilated rooms with sunshine shut out. After the disease is once established in the body, living according to the above rules cures more than half of all those who continue the hygienic life, while very few of those who seek help from medicine and follow the ordinary mode of living recover.

How to cure Consumption. — A pain in the chest, a hacking cough, especially in the morning, loss in weight, and an evening temperature of about 100 degrees or more are strong evidences of consumption if they continue a month or more. A physician should be consulted. Long experience has shown that patent medicines are of no use whatever for the consumptive. Some may seem to help for a time because of the alcohol or other tonic they contain, but the help is only temporary, and many of them hasten the progress of the disease. Scientists agree that the use of any alcoholic drink advertised to cure consumption only makes it worse, because the alcohol has been shown to weaken the germ-killing power of the blood.

Fig. 191. — Open shed facing southward where the consumptive patients breathe pure air all day.

The one treatment which has been tried by over 100,000 patients and found most successful, is living a hygienic life to increase the germ-killing power of the blood. Keeping in the fresh air by day and by night, drinking daily a quart or more of rich milk containing a half dozen raw beaten eggs, in addition to eating three nutritious meals, and exercising according to strength has cured fifty-five per cent of the tubercular patients taking the treatment in the early stages of the disease.

The Danger from a Consumptive. — If proper care is taken, there is but little probability of contracting consumption from living in the same house with a patient. No germs are given off in the ordinary breathing, and in coughing, a cloth to be later burned, should be held before the mouth. The sputum must be received into a paraffined paper cup with a cover to keep out the flies and burned at the end of the day. More than 10,000,000 germs are known to be given off daily by some patients. The drinking cup and other table ware should be scalded immediately after use. Observing these precautions and living a more hygienic life has decreased the yearly deaths from tuberculosis in this country one fourth during the last fifteen years.

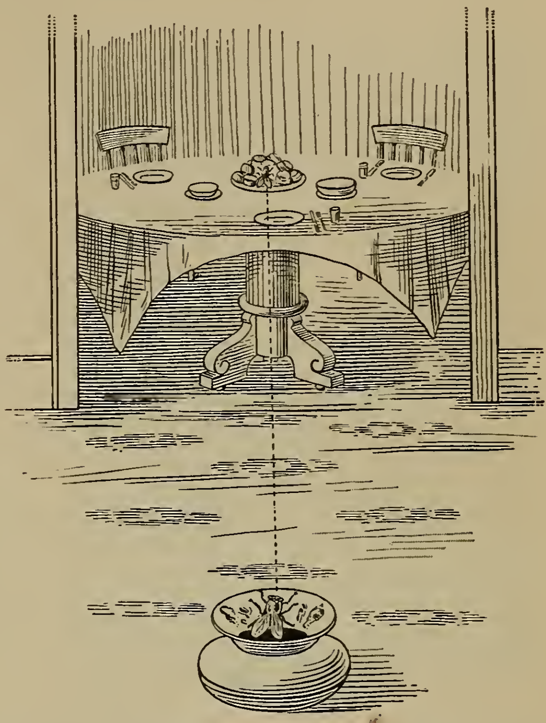


FIG. 192. — Showing why open spittoons should not be used by consumptives or any other persons.

Artificial Method of Making the Body Immune. — Safety from certain diseases is acquired by inoculation with antitoxins or vaccines. *Inoculation* means injecting a

substance under the skin. In 1880 Pasteur discovered that when a healthy chicken was inoculated with cholera germs weakened by exposure to the air, the bird became only slightly ill instead of dying, as was the case when fresh germs were used. When the same bird was inoculated later with strong germs, no sickness whatever resulted, because the growth of weak germs had given the body tissues time to produce a substance destroying the cholera germs. This process of rendering a person immune to a severe form of a disease by inoculating him with weak germs is known as *vaccination*.

Fig. 193. — Edwin Jenner, whose discovery of the method of vaccination has prevented millions from suffering from the loathsome disease of smallpox.

Millions of dollars' worth of cattle have been saved by vaccinating them against anthrax. Since 1904 vaccination of calves against tuberculosis has been tried with great success.

Vaccination for Smallpox. — About the year 1800 Jenner, of England, discovered a method of preventing smallpox by inoculating a person with the germs of *cowpox*. The cowpox germs are the human smallpox germs after they have become weakened by being grown in the

tissues of the cow. Prior to the practice of vaccination, smallpox was the worst of human maladies. Scarcely any one lived beyond the age of thirty years without being attacked by the disease, and one in every seven who suffered from it died, while many others were made deaf or blind. Macaulay describes its ravages in the following words: "That disease over which science has since achieved a succession of glorious and beneficent victories was then the most terrible of all the ministers of death. The havoc of the plague had been far more rapid; but the plague had visited our shores only once or twice in living memory; and the smallpox was always present, filling the churchyard with corpses, tormenting with constant fears all whom it had not yet stricken, and leaving on those whose lives it spared the hideous traces of its power." In 1721 more than half of the inhabitants of Boston had the disease, and a few years later 18,000 of the 50,000 residents of Greenland died of this terrible malady. It killed 60,000,000 inhabitants of Europe in the eighteenth century.

During the years 1874–1894 Austria, because it did not compel its people to be vaccinated, lost 239,800 of its citizens by smallpox. During the same years Prussia compelled vaccination, and lost only 8500 by smallpox.

To-day smallpox is a rare disease, because vaccination properly performed absolutely prevents it. In the smallpox epidemic of 1902 in Philadelphia none of the 50 vaccinated nurses caring for the smallpox patients took the disease. In Germany, where the law compels every person to be vaccinated twice, the deaths from smallpox

are only one twentieth as great in proportion to the population as they are in the United States. Every one, unless in ill health, should be vaccinated in infancy and again in the twelfth year or oftener if near a case of smallpox.

Hydrophobia, likely to develop from the bite of a rabid dog, may be prevented by taking the Pasteur treatment, which consists in several vaccinations with weak hydrophobia germs.

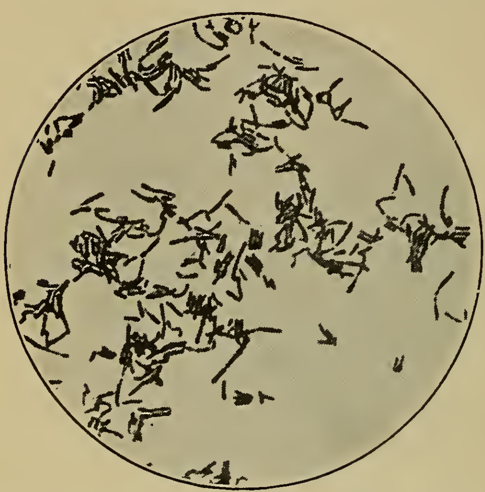


FIG. 194. — Germs of diphtheria. Photographed through the microscope.

Antitoxins. — Other means of preventing some diseases or curing them are by using antitoxins secured from the blood of domestic animals. *Diphtheria antitoxin* is secured from the horse by inoculating it several times at intervals of a day or more with some broth in which diphtheria germs have been growing and have given off their poisons, called *toxins*. Before the broth is used the germs are removed by a filter. Each successive dose given the horse is increased, and to overcome these constantly larger quantities of poison, it develops in its tissues a substance known as antitoxin. This occurs abundantly in its blood, a gallon or more of which is later drawn from a vein in its neck. After the corpuscles are allowed to settle, the clear part, called *serum*, containing the anti-

toxin, is put up in tubes and sent out to physicians to prevent and cure diphtheria.

Antitoxin does not affect the heart, as many people suppose, but the poison of the diphtheria germs does. Antitoxin used in the early stages of the disease is a sure cure in nearly all cases. It saves the lives of 45,000 children in Germany every year. The mortality from diphtheria is only one third as great as in former years. Antitoxin saves the lives of more than 10,000 persons annually in the United States. In the Boston City Hospital before the use of antitoxin 46 per cent of the diphtheria patients died, but with the use of antitoxin since 1895 only 12 per cent die.

Hospitals and Sanatoria. — In nearly every city in the United States with a population of over 20,000 there are one or more hospitals. These are institutions with nurses, surgeons, and physicians and all appliances for the treatment of the sick and wounded. Serious operations are usually performed with more safety and less expense at the hospital than at the home. The thousands who are living in hotels and private boarding houses find the hospital a convenient place to receive them in case of sickness. A specially equipped wagon, called an *ambulance*, is kept by most hospitals for conveying the sick and injured to the institution.

Although many persons using the hospitals pay for their accommodations, yet there are hundreds who cannot afford the expense, and are therefore treated free. A department of the public hospitals, known as the *dispensary*, furnishes free of charge treatment and medicines to the poor making application at certain hours each day.

Public hospitals are largely maintained by the generous gifts of benevolent persons or by the government. A hospital for taking care of those not in their right mind is an *insane asylum*. Each state usually supports one or two such institutions. A *sanatorium* is a hospital where the sick are treated largely by the use of fresh air, nutritious food, proper exercise, and baths.

It is not only humane to prevent suffering, but it is economy for the government to endeavor to prevent sickness and cure the sick, because the average work of each person done between the ages of 21 and 75 years is worth to the country about $4000. The captivity of the Jews was delayed 122 years by the plague that fell upon the army of Sennacherib. Herodotus, the great Greek historian, tells us that nothing reduced the Athenian power more than the plague or contributed more largely to the downfall of Athens. One of the greatest assets of any nation is healthy citizens.

The Board of Health. — In nearly every community there are several persons appointed to protect the health of the people. These persons constitute the Board of Health. One of their number, the health officer, is required to see that certain laws are enforced to prevent the cause of sickness and the spread of contagious diseases. One of his duties is to placard all houses in which are contagious diseases, to quarantine the inmates, and to disinfect the home after the sick have recovered.

It is the duty of the health board to see that the garbage is burned or buried and the sewage properly disposed of, to prevent the sale of unhealthful milk and provide for a pure supply of water.

All persons should obey the instructions of the board of health and endeavor to assist them in preventing much sickness which frequently afflicts every negligent community.

HEALTH RULES FOR SCHOOL CHILDREN

FROM THE MICHIGAN PUBLIC HEALTH QUARTERLY

1. Health is wealth.
2. Do not put pins in your mouth.
3. Do not hold money in your mouth.
4. Do not put your fingers in your mouth.
5. Do not put pencils in your mouth or wet them with your lips.
6. Do not wet your finger in your mouth when turning the leaves of books.
7. Do not put anything into your mouth except *food* and *drink*.
8. Never spit on your slate, or upon the floor or sidewalk.
9. Do not pick your nose, or wipe it with your hand or sleeve.
10. Keep your face, hands, and finger nails clean.
11. Keep the interior of your body clean by allowing nothing to go into it excepting *pure food* and *pure drink*.
12. Don't keep your rubbers on in the schoolroom.
13. Don't sit with wet feet or damp clothing; resort to the stove or register until they are dry.
14. Do not swap parts of apples, candy, chewing gum,

half-eaten food, whistles, or anything that is to be put in the mouth.

15. Never cough or sneeze in a person's face. Turn your face to one side, and hold a handkerchief before your mouth.
16. When drinking rinse out the cup, and empty what water you leave into the wash basin or sink.
17. Breathe only fresh air day and night — simply avoid drafts.
18. Breathe, sit, stand, and walk correctly. In so doing you will do more to prevent consumption than all the physicians combined. A good pair of lungs is the most efficacious barrier to this disease.
19. Go to bed early, rise early; and take plenty of "physical culture," helping father and mother before and after school with the "chores."
20. Study the physiology — to know how to use rightly and take proper care of every part of the body.

Questions

1. Name three methods of preventing disease. 2. Why should the germs in the excretions of the sick always be killed? 3. How should the excretions be treated? 4. Who are largely responsible for the many deaths from typhoid fever? 5. Why should open spittoons not be used? 6. How should the spit of the sick be disposed of? 7. Why and how should those sick with contagious diseases be isolated? 8. Name some antiseptics. 9. What is an antiseptic? 10. Why should a room containing a person sick with a contagious disease not be swept? 11. How should a room be disinfected? 12. Explain how the person should be disinfected. 13. When one case of typhoid occurs in a family, why do other members of the house often get the disease? 14. What five kinds of disease germs may usually be kept out of the body? 15. How may these germs be kept out of the body? 16. When should one use only boiled water? 17. How may the germs

of malaria and yellow fever be kept out of the system? 18. Give two differences between the malaria mosquito and the common mosquito. 19. How may the plague and leprosy be transmitted? 20. In what way are the germs given off by those sick with diphtheria and tuberculosis? 21. Why should every one hold a handkerchief over the mouth when coughing? 22. How is water filtered and what is the result? 23. What facts show that filtering river water saves much sickness and death? 24. How are disease germs often killed within the body? 25. How may the body be rendered safe against some diseases? 26. How frequently are the germs of tuberculosis present in the body? 27. Give the number of people dying annually from tuberculosis. 28. Explain the method of preventing tuberculosis. 29. Give evidence showing that hygienic living will in most cases prevent tuberculosis. 30. Why is it better for tubercular patients to sleep out of doors? 31. How may a person often distinguish consumption from a cold or catarrh? 32. Are patent medicine or alcoholic drinks of any use in curing consumption? 33. Give three great helps in curing consumption. 34. Give evidence showing that in most cases consumption may be cured in the early stages. 35. Can one live in the same house with a consumptive without danger? 36. What is vaccination? 37. How is smallpox prevented? 38. State some facts showing that smallpox was once a much-dreaded disease. 39. What facts show that vaccination for smallpox prevents the disease? 40. What care should be used in vaccinating? 41. Where is antitoxin for diphtheria secured? 42. Of what use is a hospital, a dispensary, or a sanatorium?

Suggestions for the Teacher

1. Write to the Department of Agriculture, Washington, D.C., for bulletins relating to tuberculosis and health. They furnish excellent material for short essays by the pupils.

2. Ask the pupils to find the young of mosquitoes by looking into any quiet ponds, tin cans, or barrels containing water. The young will hatch into full-grown mosquitoes in a few days if kept in a jar of water. Let the pupils suggest plans for destroying mosquitoes.

3. Ask the pupils to note how many persons spit upon the sidewalk and floor of cars and public buildings. Ask the class to think the matter over and suggest a remedy for the uncleanly habit. Ask some of the boys to count the flies seen feeding in spittoons.

XXV. ACCIDENTS AND EMERGENCIES

Importance of Early Aid. — It is estimated that over 10,000 people die annually in this country from lack of the quick aid after injury which this chapter explains. During the late hours of night it is not easy to secure a physician in less than an hour, and in the country many residents have no doctor within five or more miles of them. The most effective aid in cases of fainting, convulsions, sunstroke, snake bite, croup, choking, bleeding, and drowning is that given during the first half hour after the person is affected.

Injuries to the eye and ear are discussed in the chapters treating of those organs. Treatment for sprains and dislocations is given in the chapter on bones.

Fainting. — Fainting may be caused by pain, fatigue, loss of blood, the sight of some gruesome object, such as flowing blood, or by a hot and badly ventilated room. The face is pale, the lips white, and the breathing is quickened, while cold sweat appears on the brow and the palms of the hands. As fainting is caused by an insufficient supply of blood to the brain, the patient should be laid flat on the floor. Then the doors and windows must be opened and the clothing loosened, while cold water is sprinkled on the face. Recovery should occur in a few minutes. As soon as the patient is able to swallow,

give sips of hot milk or water. Swallowing stimulates the heart. Do not give alcohol.

Intoxication. — This may be caused by the drinking of beer, wine, whisky, hard cider, or patent medicines containing alcohol. The victim seems half asleep, eyes are red and bloodshot and have a fixed stare. The breathing is slow, and the smell of liquor is often in the breath. The stomach should be emptied by giving the patient a tablespoonful of mustard in warm water to make him vomit. Then let him sip slowly two or three cups of strong hot coffee, after which he may be put to bed.

Fits or Convulsions. — There are in this country about 135,000 people who are attacked at intervals of several hours or days with *epileptic fits*. The victim is unable to control his muscles and throws his arms and legs in all directions. He seems to be in agony, but really does not suffer. No remedy is effective. The patient should be prevented from injuring himself, and especially from biting his tongue, by placing a folded handkerchief between the teeth. The fit will last only a few minutes.

Convulsions or *spasms* are usually ailments of children less than five years of age. They are frequently caused by eating indigestible foods, such as fruits and nuts, which are not well chewed. The child jerks at first with contractions of the muscles and then struggles violently. It is unconscious, and therefore does not suffer. Relief is usually given by placing the feet and legs in water as hot as the hand can bear and applying a cloth wrung out of cold water to the forehead and temples. The wet cloth should be changed every minute or two to keep the head as cold as possible. The bowels should be moved.

Sunstroke and Heat Exhaustion. — Sunstroke is caused by fatigue and exposure to the rays of the sun on a hot day. The patient feels giddy at first, then weak and sick at the stomach. He may become sleepy and more or less unconscious. The eyes are bloodshot and the skin is hot and dry. The remedy is to keep the patient

FIG. 195. — Method of producing artificial breathing.

cool by throwing cold water on the head, neck, and chest or by wrapping sheets wrung out of cold water around him. Chopped ice wrapped in flannel may be applied to the head.

In heat exhaustion the skin is cold and pale, and therefore cool applications should not be used. Drinking strong hot coffee and rest in bed are most helpful.

Alcoholic drink should never be given for sunstroke or heat exhaustion.

Suffocation from Gas or Drowning. — Suffocation may be produced by remaining in a closed room where the gas used in lighting is escaping, or by the gas from a coal stove when the chimney draft is closed. The first remedy is fresh air in abundance. All tight clothing must be loosened and artificial respiration begun at once by laying the patient face downward with his chest on a thick folded coat or blanket. Then stand astride him, and placing one hand on either side of the lower ribs, let the weight of your body fall forward slowly, and thus press out the air in the lungs and mucus in the larynx. The hands should not be moved from their places, but the pressure should be slowly relaxed by bringing your body to a more upright position so that the air will be drawn into the lungs. The operator should bend forward and backward, pressing on the ribs and relaxing the pressure about fifteen times a minute, while another person is dashing cold water upon the head and rubbing the body to warm it.

In case of apparent drowning the artificial breathing should be begun at once without making any effort to get the water out of the internal organs. The wet clothing should be removed as soon as possible, and dry blankets used with hot bricks to warm the body. Strong hot coffee is useful as a stimulant as soon the patient can swallow.

The Clothing on Fire. — To extinguish the burning clothing of a person, it is necessary to wrap him in a coat, quilt, or blanket so as to exclude the air. Rolling him

over and over in the dirt and dust is also effective. As the patient is in pain and much excited, he is likely to break loose and run out into the open air unless held firmly. If the burning is sufficient to cause the clothes to adhere to the skin in places, these should be soaked in a quart of water to which a teacupful of washing or baking soda has been added, while the physician is sent for. The slightly burned places may be anointed with vaseline.

Burns and Scalds. — Hot water or escaping steam may cause severe *scalds*. *Burns* are produced by fire, hot objects, acids, and alkalies. Every household should keep on hand a quart bottle filled with one pint of limewater and one pint of linseed oil well shaken. This is *carron* oil, the most effective of all remedies for burns and scalds. Linen cloths or pieces of lint are soaked in this and applied at once to the burn. Cloths spread with vaseline or soaked in kerosene or in a pint of water containing a half teacupful of soda and bound on the injured skin give great relief.

Burns from acids should be first drenched with water containing a little soda before the above remedies are applied. Burns from alkalies should be washed with water containing a little vinegar before using the other remedies.

Frostbite. — Frosted ears, fingers, and toes are very common, and often cause much discomfort for several weeks if not properly cared for. The parts affected should be rubbed with snow or ice water in a cold room until a tingling sensation is felt. This shows that the circulation which had stopped has returned, and the patient may then be brought nearer a warm stove.

Cuts and Nail Punctures. — A small cut or the puncture of the skin by a nail has been known to result in death. This was due to bacteria, which cause the pus or white matter in a sore. If a wound bleeds freely, the germs are likely to be washed out. In case the skin is torn or punctured by a blunt instrument like a nail the wound should be well washed out by forcing into it with a syringe turpentine or a five per cent solution of carbolic acid. A clean linen cloth folded several times should then be laid over the wound and tied firmly in place. If the wound causes a considerable flow of blood, it should be stopped, as directed in the chapter on the circulatory system. Do not use unboiled water or a soiled cloth or hands in cleaning a wound.

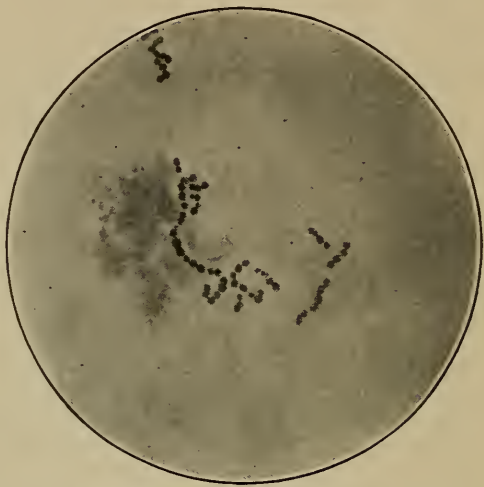


Fig. 196. — Bacteria which get into wounds and produce blood poison.

Bruises. — These result from blows on the person with blunt instruments. The part affected swells and becomes more or less black and blue, owing to the bursting of the blood vessels. The dark coloration may be prevented to a certain extent by applying for a half hour cloths wrung out of very hot water. The cloths should be changed every two or three minutes. Cold water will serve almost as well as hot water.

Bleeding from the Nose. — This is rarely dangerous, and no remedy is necessary unless the blood continues to flow for an hour or more. The patient should not lean over, but sit erect or with the head thrown slightly backward and use a damp cloth to soak up the blood. Broken ice tied in a cloth and applied to the back of the neck and between the shoulder blades is the best remedy. Cloths

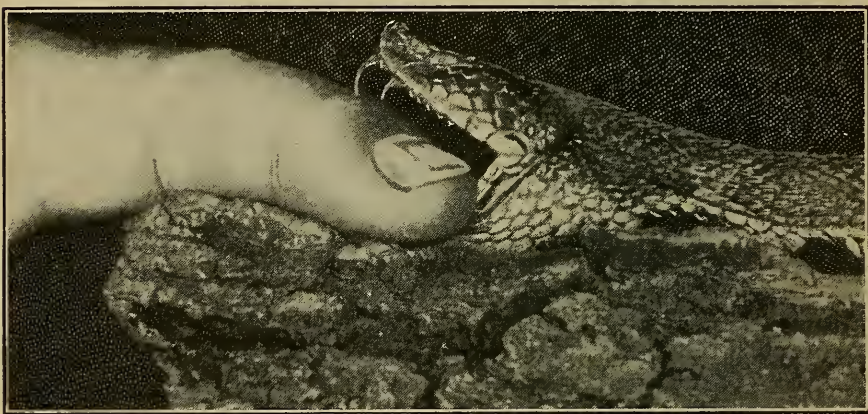


FIG. 197. — How a copperhead snake or pilot sinks its poison fangs or teeth into the flesh.

wrung out of cold water may be held to the back of the neck and over the nose and forehead. If bleeding continues, the nose should be held shut and the mouth used in breathing.

Bites and Stings of Animals. — The bite of a healthy dog or cat should be treated like any other wound. If there is any reason to suppose the dog is rabid, a physician should be called to cauterize the bite and arrange to vaccinate the patient for hydrophobia.

The bite of a *venomous* or *harmful snake*, such as a *copperhead*, *rattlesnake*, or *moccasin*, usually results in death in

from 12 to 24 hours unless some remedy is used. A physician should be called at once. The best means of avoiding serious results if the bite is on a limb is to tie just above the punctures a loose bandage and twist it tight by turning a stick slipped underneath. Then a cut lengthwise of the limb two inches long and nearly a half inch deep should be made through the wound to let out the poisoned blood and lymph. The application to the bite of crystals of permanganate of potash is of great value. If the physician does not arrive soon, the taking of a tablespoonful of whisky at intervals of a half hour until the patient feels the effect tends to keep up the action of the heart.

Some of the snakes, such as the water snake, without any poison, bite sufficiently to make the blood run, but no serious results follow. The bite of a poisonous snake can be recognized by the presence of two little holes made by the two fangs in the upper jaw of the reptile. The bite of a spider need cause no alarm unless it is one of the large Southern spiders.

The *stings* of *wasps* and *bees* are not dangerous, but may cause considerable swelling and pain. This may be relieved by bathing the part in ammonia or a strong solution of baking soda in water.

Choking. — The lodging of a button, thimble, or a piece of meat in the throat may cause death in a few minutes. A blow with the fist on the back between the shoulder blades will cause the air to rush out of the lungs and sometimes expel the object. If the sufferer is a child, it should be held by the feet with the head hanging downward while two or three blows are struck on the back of the chest.

Sometimes the object is in the upper part of the throat and may be pulled out with the finger or the end of a bent spoon handle. When hard objects, like keys or tacks, are swallowed, plenty of hard-boiled eggs, bread, and potatoes should be eaten. These will prevent the jagged points of the object from injuring the intestine.

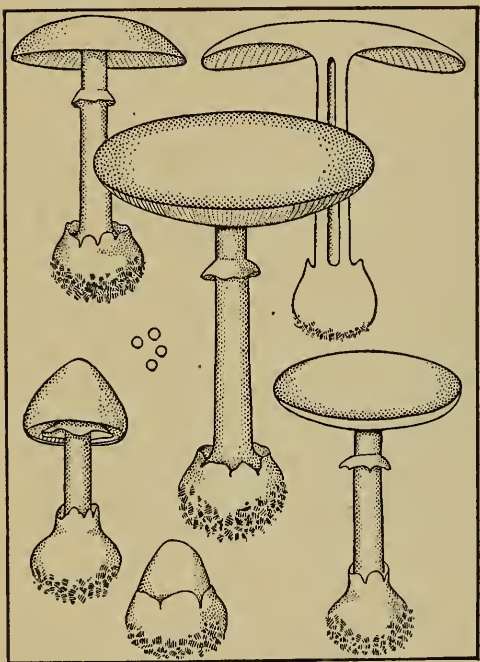


FIG. 198. — The death cup, a poisonous mushroom which has killed more people than any other. The different forms show the plant at different ages.

Croup. — There are two kinds of croup. *False* or *catarrhal croup* usually comes on suddenly at night. The child has a hoarse metallic cough and may at times have to gasp for breath. Relief may be quickly given by making a tent of a sheet or quilt in which the child should be held, while a tin cup partly filled with a mixture of equal parts of vinegar and water is kept boiling or very hot on an oil stove in the tent. A common lamp may be used to do the heating if two nails for the support of the cup are laid across the top of the chimney to prevent smoking.

Membranous croup is a form of diphtheria in which there is a membrane formed in the narrow part of the throat.

Poisons and Emetics. — An emetic is a substance which, when taken into the stomach, causes vomiting. Since the first step in treating a person poisoned is usually to free the stomach of its contents, an emetic must be given. It is well to remember that no emetic should be used when from stains or burns on the fingers, lips, or mouth, or by any other means it is known that the person has taken a strong alkali or an acid.

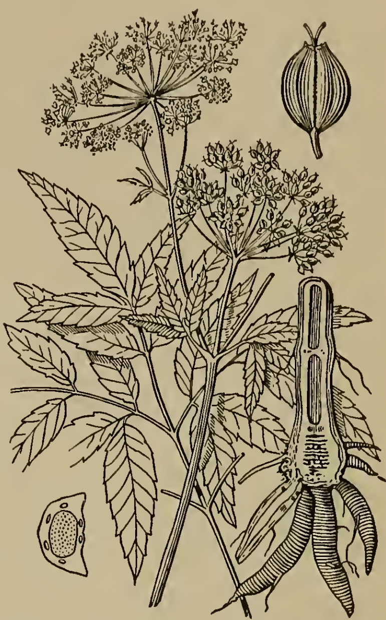


FIG. 199. — Water hemlock, whose poisonous roots have killed a number of children. The height of the plant is from three to five feet and the leaves are two or three inches long.

The following are *good emetics:* a tablespoonful of mustard in a glass of warm water; two tablespoonfuls of common salt in a glass of warm water; a pint of warm water followed by tickling the back of the throat with a feather or other soft object. Poisons cause the death of about 8000 persons annually.

Special Poisons. — The remedy for *carbolic acid* poisoning is a tablepoonful of "salts," properly called Epsom salts, or sulphate of magnesia, in a glass of warm water. Immediately after a pint or two of milk should be swallowed. A cup of strong coffee may then be given to stimulate the heart. *Ammonia* or *potash* poisoning may be helped by giving the patient the juice of two or three lemons or

oranges, or a glass of water containing two tablespoonfuls of vinegar.

Arsenic poisoning is common, as this poison forms a part of Paris green, many rat poisons, and preserving fluids. After giving an emetic, a glass or two of soapy or greasy water should be taken. A cup of water which has been several days in a rusty kettle or contained rusty nails or iron of any kind should be drunk.

FIG. 200. — Poison ivy, which is common along old fences and in waste places. Touching it or sometimes even coming near it poisons the skin of many persons.

Certain plants found growing in yards and fields contain strong poisons. The *deadly nightshade*, some kinds of *mushrooms*, *holly berries*, *jimson weed*, and *water hemlock* have caused the deaths of many persons, especially children. The roots, berries, or leaves of wild plants should never be chewed or eaten unless they are known to be harmless, as there are more than thirty poisonous plants growing in the United States. The best remedy for their poisons is an emetic, followed by a large dose of Epsom salts to cause the harmful materials to pass out of the alimentary canal. A physician should be called at once.

The *external poisoning* of the skin by *poison ivy* or *sumac* often results seriously. Numerous pimples or blisters

may form with more or less redness and swelling, sometimes sufficient to close the eyes. Poison ivy may be distinguished from similar vines by the division of each leaf into three leaflets instead of five. If one has been touching the plant, poisoning may usually be prevented by washing as soon as possible the face and hands with soapsuds. A good remedy for the poison is the application to the affected parts of a cloth soaked in a half pint of equal parts of alcohol and water containing as much sugar of lead as will dissolve.

Questions

1. Why should every one understand how to give first aid to the injured? 2. What may cause fainting? 3. How should a fainting person be treated? 4. What is the remedy for intoxication? 5. What is the treatment for epileptic fits? 6. How can you tell when a child is having a spasm? 7. Explain the treatment for a spasm. 8. Describe the difference between sunstroke and heat exhaustion. 9. How is a patient to be treated in case of suffocation? 10. Explain the relief for scalds and burns. 11. What is the remedy for frostbite? 12. Describe the treatment for cuts and nail punctures. 13. How should a bruise be treated? 14. Give some methods for stopping the flow of blood from the nose. 15. Why is the bite of a black snake, garter snake, or common water snake harmless? 16. How is the bite of a copperhead or rattlesnake to be treated? 17. Describe the relief for choking. 18. How does false croup differ from membranous croup? 19. What relieves false croup? 20. Name some emetics. 21. Of what use are emetics? 22. When should an emetic not be given? 23. What is the remedy for carbolic acid poisoning? 24. Name some poisonous plants. 25. Explain how poisoning of the skin by poison ivy may be relieved.

Suggestions for the Teacher

Any one able to render efficient first aid to the injured is a valuable person in any community. It is worth while for the teacher to take time to impress upon the children what to do when the various

common accidents of life occur. This may be done by full and clear explanations followed by careful questioning of the pupils. Actual demonstrations of how to proceed in case of certain accidents, such as fainting, choking, burns, and wounds, may be given, using some pupil for the subject.

Permitting the children to tell of accidents that have occurred in their own families and the results of the wrong or right treatment given, may often help to emphasize the importance of understanding what this chapter teaches. Procure from the Department of Agriculture at Washington the free pamphlets on poisonous plants and mushrooms.

PRONUNCIATION AND EXPLANATION OF DIFFICULT WORDS

Ab do'men: that part of the body between the chest and legs.

Ab dom'i nal: pertaining to the abdomen.

Ad'e noids: spongy growths in the upper part of the throat back of the nose.

A dul ter a'tion: making any substance impure by mixing with it something of less value.

Al bu'min: one kind of proteid. It occurs in all cells of the body.

Al'co hol ism: a diseased condition of the body caused by using much strong drink.

Am'bu lance: a wagon for carrying the sick.

A mœ'ba: a tiny one-celled animal which is constantly changing its shape.

A mœ'boid: like an amœba.

A nat'o my: the study treating of the parts of the body.

An ti sep'tic: that which stops the growth of bacteria.

An ti tox'in: a substance which prevents certain poisons from harming the body. *Anti* means against, and *toxin*, a poison. Antitoxin for diphtheria makes the poison given off by the diphtheria germs harmless.

Ap'o plex y: sudden loss of motion and fainting caused by the clogging or bursting of a blood vessel in the brain.

Ap pend i ci'tis: an inflammation of the vermiform appendix.

A'que ous (*a'kwe us*): the kind of humor or watery fluid in the front part of the eyeball.

A rach'noid (*a rak'noid*): a delicate membrane covering the brain and spinal cord.

Asth'ma (*as'ma*): a disease in which the air tubes are squeezed so tight by their muscles as to hinder proper breathing.

A stig'ma tism: a condition of unequal curvature in the lens or cornea.

Au′di to ry: relating to the ear.

Ax′on: the long process of a nerve cell carrying the stimulus from the cell body.

Ba cil′li: rodlike bacteria such as the germs of diphtheria and consumption.

Ba cil′lus: singular of bacilli.

Bac te′ri a: tiny one-celled plants often called germs or microbes.

Bi cus′pid: another name for a premolar tooth, also the valve on the left side of the heart.

Brach′i al (*brak′i al*): pertaining to the arm.

Bron′chi (*bron′ki*): plural of bronchus.

Bron′chi al tubes (*bron′kĭ al*): the air tubes of the lungs.

Bron chi′tis (*bron ki′tis*): inflammation of the bronchial tubes.

Bron′chus (*bron′kus*): one of the two branches of the windpipe entering the lungs.

Caf fe′in: a bitter substance in coffee and tea.

Cal′o rie: a heat unit.

Ca nine′ teeth: the stomach or eye teeth.

Cap′il la ry: the smallest blood tube.

Car bo hy′drate: any food stuff made mostly of starch or sugar.

Car bol′ic ac′id: a poison which burns the skin. It is used as a disinfectant.

Car′di ac: near to or belonging to the heart.

Ca′se in: the proteid in milk and cheese.

Ce ment′: the substance covering the dentine in the roots of the teeth.

Cer e bel′lum: the little brain; the large lobe of the hind brain.

Cer′e brum: the large part of the brain.

Chol′e ra in fan′tum: a dangerous disease of children usually caused by impure milk, or dirty milk bottles.

Cho′roid (*ko′roid*): the middle coat of the eyeball.

Chyle (*kile*): the digested food in the intestine.

Chyme (*kime*): the partly digested food leaving the stomach.

Cil′i a: tiny hairlike projections in the nose and air tubes. They catch dust particles and mucus, and move them outward by constantly waving.

Clav′i cle: collar bone.

Co′ca ine (*ko′ka in*): a narcotic made from coca leaves.

Coc′ci (*kok′si*): spherical bacteria.

Coc'cyx (*kok'siks*) : the small bone at the end of the spinal column.
Coch'le a (*kok'le a*) : coiled part of the internal ear.
Com'mis sure : a band of fibers in the brain or spinal cord.
Con sti pa'tion : a condition in which the refuse part of the food hardens and is not easily expelled daily from the large intestine.
Con sump'tion : tuberculosis of the lungs.
Con ta'gious (*con ta'jus*) : catching.
Cor'pus cal lo'sum : a band of fibers joining the two halves of the cerebrum.
Cor'pus cle (*cor'pus s'l*) : a blood cell.
Cra'ni al : pertaining to the cranium.
Cra'nium : the bones surrounding the brain.

Den'tine (*den'tin*) : the hard inner part of the teeth.
Di'a phragm (*di'a fram*) : the muscle separating the cavity of the chest from that of the abdomen.
Di ar rhe'a : a condition in which the bowel excretions contain too much liquid.
Di as'to le : the expanding of the walls of the heart.
Di'et : a course of food.
Dis in fect'ant : a substance which kills germs.
Dis pen'sa ry : a place where the poor receive free medical advice.
Dys'en ter y : inflammation of the large intestine with the discharge of some blood.
Dys pep'si a : a failure to digest the food properly.

E met'ic : an agent which causes vomiting.
E mul'sion : a liquid full of fine particles of fat.
Ep i the'li um : the layer of cells covering a free surface.
E soph'a gus (*e sof'a gus*) : the tube taking the food from the throat to the stomach.
Eu sta'chi an tube (*u sta'ki an*): the tube from the throat to the middle ear.
Ex cre'ta : the natural discharges from the body. The excreta of the bowels are called feces.

Fel'on : an inflammation of the periosteum.
Fem'o ral : pertaining to the femur.
Fi'brin : a proteid in coagulated blood.
Fi brin'o gen : the substance in the blood from which fibrin is formed.

Fis′sure (*fish′ur*): a crevice between the parts of an organ.

Fo′cus: the point where the rays of light meet after passing through a lens.

Fol′li cle (*fol′li k′l*): a little pouch.

For mal′de hyde: a germ-killing gas. The gas dissolved in water makes formaldehyde solution or formalin.

For′mal in: a solution of formaldehyde gas in water. It is a much better disinfectant than sulphur.

Germs: bacteria and also tiny animal parasites.

Gly′co gen: animal starch.

Grippe (*grip*): a contagious disease often called influenza.

Hem o glo′bin: the red coloring matter of red blood corpuscles.

Hem′or rhage (*hem′or raj*): flow of blood from a vessel.

He pat′ic: pertaining to the liver.

Hy′dro gen: a gas forming two thirds of water.

Hy gi en′ic: healthful.

Il′i ac: pertaining to the ilium or top of the hip bone.

Im bi bi′tion (*im bi bish′un*): drinking in.

Im mune′: safe from disease.

In ci′sors: front teeth.

In flam ma′tion: the condition of a tissue which becomes gorged with blood as a result of irritation, usually by germs.

In oc u la′tion: planting the germs of disease in the body.

In vol′un ta ry: unable to control.

I′ris: the colored curtain around the pupil admitting light to the eye.

Ju′gu lar vein: the large vein in the neck.

Lach′ry mal (*lak′ri mal*): the name of the tear gland and its duct.

Lac′te als: that part of the lymphatic system carrying the food from the intestines to the thoracic duct.

Lar′ynx (*lar′inks*): the voice box at the top of the windpipe.

Lau′da num: a solution of opium in alcohol.

Lu′pus: tuberculosis of the skin.

Lym phat′ics: small vessels for returning escaped blood to the veins in the neck, and carrying food from the intestines.

Ma la′ri a: a disease attended with chills and fever.

Mas′sag ing (*mas′saj ing*): pressing and squeezing any part of the body in a definite way.

Me dul′la ob lon ga′ta: the stem of the brain.
Med′ul la ry: the name given to the cavity in a long bone.
Men in gi′tis: an inflammation of the membranes of the brain or spinal cord caused by bacteria such as germs.
Mi′crobes: bacteria and other germs.
Mi′tral: the bicuspid valve in the heart on the left side.
Mo′tor: the name of those nerves and that part of the brain controlling the muscles of the body.
Mu′cous mem′brane: that which lines cavities of the body touched by air.
Mu′cus: the secretion of glands in the mucous membrane.

Neu′ron: a nerve cell with all its processes. It may be three feet long.
Nic′o tine (*nic′o tin*): the poison in tobacco.
Ni′tro gen: a gas forming four fifths of the air.
Ni trog′e nous (*ni troj′e nous*): said of foods containing much proteid. Peas, milk, beans, and lean meat are nitrogenous foods.

Oc cip′i tal (*ok sip′i tal*): name of a bone at the back of the head.
O le o mar′ga rine: a substitute for butter. It is made of tallow or lard churned with milk and cotton-seed oil.
Ol fac′to ry: pertaining to the nose.
Op′tic: relating to the eye.
Or′bit al cav′i ty: the cavity for the eyeball.
Or′gan: any part of the body having a definite work to perform.
Os mo′sis: the oozing of a liquid through a membrane, separating it from another liquid.
Ox i da′tion: the union of another substance with oxygen.
Ox′i dize: to burn or unite with oxygen.

Pa pil′la: a little elevation on the skin or mucous membrane.
Pa ral′y sis: loss of power to move or feel in any part. It is caused by injury to the nerves, cord, or brain.
Par′a sites: animals or plants that feed upon other living animals or plants without at once destroying them.
Par e gor′ic: a solution of water, alcohol, opium, and other drugs.
Pa ri′e tal: a bone on the side of the head.
Pa rot′id: the salivary gland below the ear.
Pas′teur: the world's greatest benefactor. He discovered the cause and prevention of disease.

Pas teur i za'tion: heating a substance to about 160 degrees for a sufficient time to kill most of the germs.

Pat'ent med'i cines: secret preparations advertised to cure disease; most of them are worthless and many are very harmful to health.

Pep'sin: a digestive ferment made in the stomach.

Pep'tone: a digested proteid.

Per i car'di um: the membrane around the heart.

Per i os'te um: the membrane around the bone.

Per i stal'sis: the movements of the intestines.

Per i to ne'um: the delicate membrane lining the abdominal cavity and holding the organs in place.

Per i to ni'tis: inflammation of the peritoneum.

Pha lan'ges: the bones of the toes and fingers.

Phar'ynx (*far'inks*): the cavity of the throat.

Phthi'sis (*thi'sis*): tuberculosis of the lungs.

Pos te'ri or: behind.

Pro'te id: a substance forming most of the dry part of the muscle.

Pro'to plasm: the chief part of every cell in plants and animals.

Pto'ma ine (*to'ma in*): a poison developed by bacteria in stale or canned food.

Pul'mo na ry: relating to the lungs.

Quack doc'tors: dishonest persons who advertise that they can cure disease.

Ret'i na: the inner coat of the eye.

Sa'crum: the bone between the hips; part of the spinal column.

Sa li'va: the slippery fluid used to moisten the food in the mouth.

Sal'i va ry glands: those glands in the head forming saliva.

Scle rot'ic (*skle rot'ic*): the tough outer coat of the eyeball.

Scrof'u la: tuberculosis of the lymph glands.

Se'rum: the clear part of blood clotted in a cup or other vessel.

Ses'a moid bones: small bones formed about the joints in the hands and feet and at the knee.

Spu'tum: the spit.

Stim'u lant: that which hastens the action of an organ without later slowing it.

Stim'u lus: an impulse or excitement carried by a nerve fiber.

Sul'ci (*sul'si*): the crevices between the folds on the surface of the brain.

Syn o'vi a: the slippery fluid in all movable joints.
Sys'to le: the contraction or squeezing together of the walls of the heart.

Tac'tile (*tac'til*): pertaining to touch.
Tho rac'ic (*tho ras'ik*): pertaining to the thorax or chest.
Tis'sue (*tish'u*): a combination of cells or of cells and fibers.
Ton si li'tis: a contagious disease of the tonsils.
Tra'che a (*tra'ke a*): the windpipe.
Trich i no'sis: a disease caused by little worms.
Tym'pa num: the middle ear.

U re'a: the chief solid in urine.
Ure'ter: one of the two tubes from the kidneys to the bladder.
U'rine (*u'rin*): the excretion of the kidneys.
U'vu la: back part of the soft palate.

Vac'ci nate: to prevent disease by putting into the body through the skin, weakened germs or the excretions of the germs causing that disease.
Vac'cine: smallpox germs weakened by growing in calves.
Ver'te bra: one of the bones of the spinal column.
Vis'ce ra: the internal organs.

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